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DESTRUCTION OF THE U.S. BATTLESHIP MAINE BY AN EXPLOSION IN HAVANA HARBOR.

An explosion, from causes yet unknown, caused the destruction of the U. S. Second Class Battleship Maine in Havana Harbor, about 9.40 o'clock on the night of February 15. The ship was at anchor in the harbor, where she had been sent by the Government on a friendly mission. Darwin R. Merritt. Immediately following the explosion the vessel commenced to sink and Captain Sigsbee gave orders to abandon the ship. Boats from the Spanish war vessel Alfonso XII, which lay at a near anchorage, and from the steamer City of Washington, came to the rescue of those who had been in the forward part of the ship and who had been blown into the water. The Spanish authorities rendered all possible aid

THE LATE U. S. SECOND-CLASS BATTLESHIP MAINE, 5,500 TONS, 9,000 HORSE POWER.

The explosion, which was not preceded by any alarm, occurred in the forward part of the ship and for this reason the deplorable loss of life was most severe among the crew. Only two of the officers of the ship are missing, Lieutenant Friend W. Jenkins, and Assistant Engineer in caring for the survivors. Roll call showed that about 250 men and two officers were killed or missing. The Maine sank rapidly, coming to rest on the mud bottom in about six fathoms. In the accompanying illustration the appearance of the wreck next morning can be seen. The after

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superstructure and portions of the midship superstructure littered with wreckage and one of the military masts showed above water. The Government at Washington at once appointed a board of inquiry, consisting of Captain W. T. Sampson, of the battleship Iowa; Captain French E. Chadwick, of the flagship New York; Lieutenant Commander W. P. Potter, of New York, and Lieutenant Commander Adolph Marix, Judge Advocate of the Court, to proceed to Havana and open a court of inquiry. Until this board has prepared a report it will not be possible to determine the cause of the explosion with any accuracy.

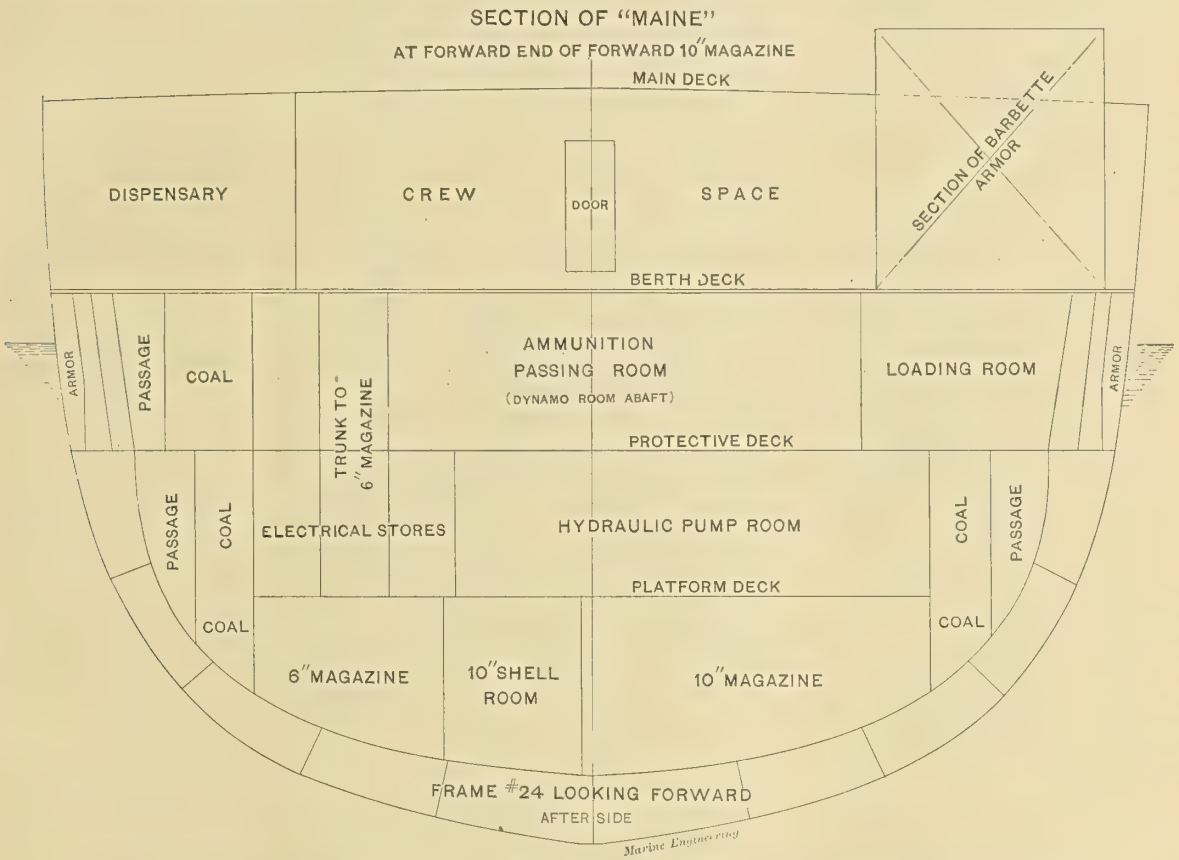
Immediately following the news of the disaster there was of course considerable speculation as to the probable cause, much of which found expression in the daily press. Wild and positive statements were freely made without a shadow of evidence in support, but the executive and legislative branches of the Government have maintained a wise and dignified reserve of official expression. It is only upon the lines of comparison between the effects of this explosion and those of other explosions, in naval experience, that any reasonable theory can be advanced. This, however, is likely to produce only empirical results, as the tendency is to make the facts agree with the theory. The work of divers who have been ordered to Havana to report to Capt. Sigsbee will, of course, narrow down the investigation, by setting at rest, for example, any question as to a boiler explosion.

Some of the causes to which the horrible disaster has been attributed may be briefly noted. A submarine explosion has found many advocates, most of whom give as an explanation the strained relations which have existed between this country and Spain, and no basis of fact. That an automobile torpedo was the cause would necessitate the belief that this expensive, cumbrous and delicately adjusted apparatus had been used by skilled naval officers, and that it would be capable of causing such destruction. The first proposition is incredible, and the second is negatived by the results of torpedo explosions as demonstrated in numerous naval encounters in the past.

Another theory is that a submarine mine was exploded under the vessel, either maliciously or by accident. There is certainly a possibility that the Spanish Government had laid mines in Havana harbor in anticipation of any hostile demonstration of an enemy, long before the visit of the Maine to Havana was even suggested. That the Maine in swinging an anchor might have fouled such a mine is not an impossibility, so far as that fact alone is concerned. But would the explosion of a submarine mine have made such a wreck of the Maine as she appears to be? Would the concussion caused by the explosion of a mass of high explosive outside the hull have fired the forward magazines of the vessel? These are questions which cannot be answered off hand. We are informed by Capt. Charles O'Neil, Chief of the Bureau of Ordnance of the Navy, that the Maine had on board no high explosives other than that contained in the heads of the Whitehead torpedoes, which were filled with guncotton. These were stored in the after magazine, abaft the engines, and manifestly were not affected by the explosion, forward, as that portion of the ship was not injured. An inspection of the sectional drawings, which we publish in the accompanying inset, will show very clearly the location of the magazines. We also here present a cross section of the forward magazine at the point where the explosion is supposed to have occurred. The powder contained in the various magazines, included 100,000 pounds of brown prismatic powder, for the big guns, divided between the two main magazines, also 8,500 pounds of coarse black powder contained in the fixed ammunition for the rapid-fire guns, distributed among the magazines, as indicated on the drawings. In the forward magazine there were also 10 in. and 6 in. shells, which contained comparatively small bursting charges, as many of them were of the armor piercing variety, with thick walls. The guncotton, of which there was 800 pounds in the after magazine was kept wet, in which state it is used in action. The dry guncotton, of which a very small quantity was kept on board for exploding the wet, was divided into very minute portions, which were distributed in various places, so that by no possibility could the ignition or explosion of one or more cause anything but slight local damages. The rapid-fire ammunition, including that for the 6-pounders, carried in the forward part of the bow magazine, consisted of the usual form of brass cartridges with primer, powder and projectile in place. It would seem not improbable that any heavy shock, such as the explosion of a mass of high explosive under the bottom, would under certain circumstances cause a discharge of this fixed ammunition. Then this supply of explosive could either be credited with directly causing the horrible loss of life and destruction of property, or of breaking down the steel bulkhead which subdivided the magazine and tearing the coverings of the great gun powder loose, causing a general explosion of the forward magazine. This powder which was of the usual slow burning description was packed in separate charges, contained in flannel bags, which in turn were contained in copper cylinders with slip covers. Some of those who were rescued testify to having experienced two distinct shocks following each other closely. This might seem to bear out the theory of an under water explosion, followed by one within the vessel. An explosion within the vessel would reasonably account for the great mass of fire and flame which accompanied the explosion, as seen by eyewitnesses, and for the breakage of windows and electric lamps in the city of Havana; and also for the tremendous noise, phenomena which do not accompany an exclusively under water explosion, such as the firing of a submarine mine would produce.

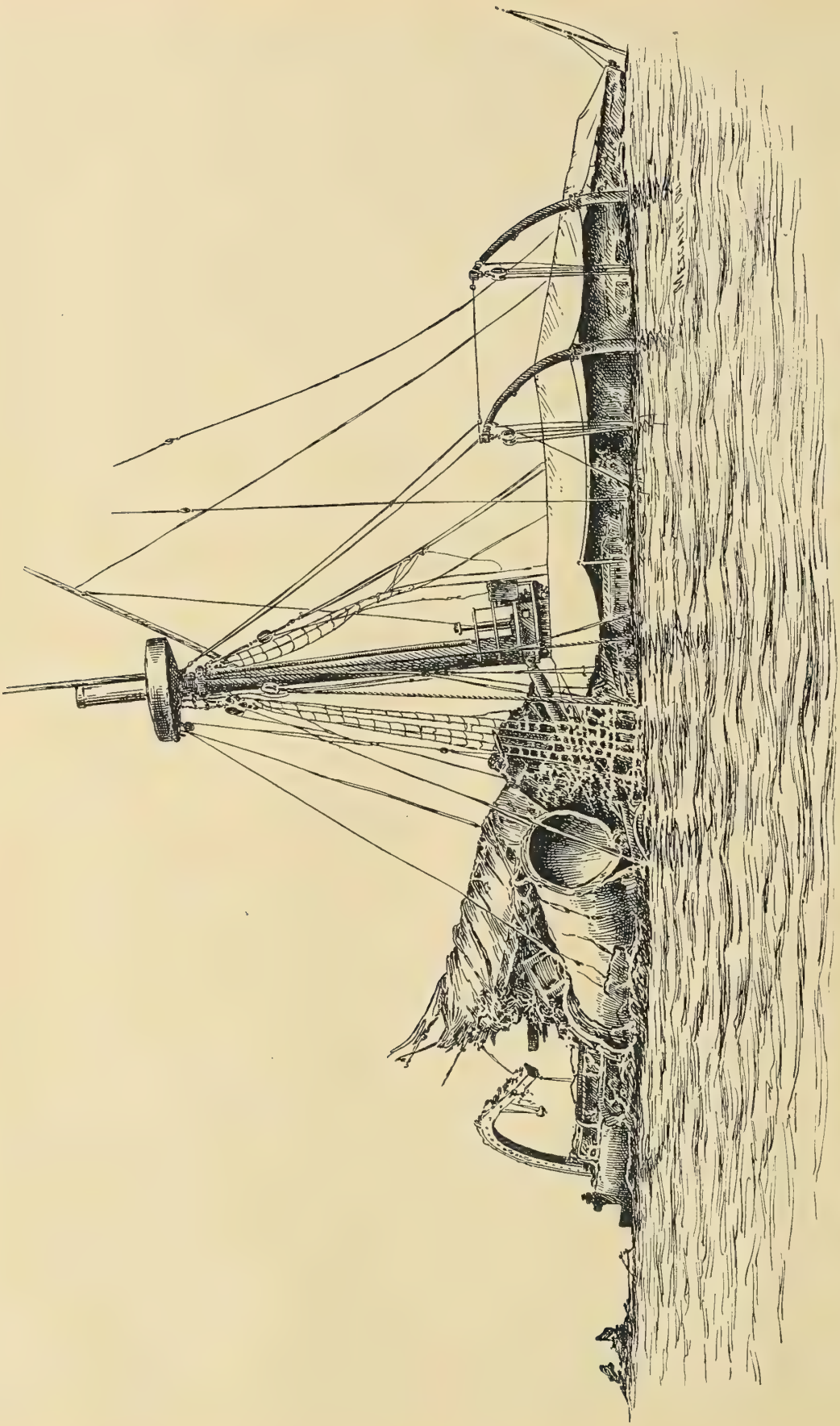
According to authentic reports the Spanish authorities suggested that a "dynamo boiler," had exploded. By this an auxiliary boiler was presumably meant. As a matter of fact, however, the Maine was not fitted with any auxiliary boiler—see description of machinery in this issue. For the dynamo engines connection was made by auxiliary steam pipes with the forward boilers, on the port and starboard sides, adjacent to the dynamo room. This was on the protective deck above the position of the forward magazine, in the hold. One of these boilers, at least, was undoubtedly in use supplying steam to the electric generating plant. Thus it would be under the immediate observation of the engineers of the ship, and it is not for a moment to be supposed that they would permit any conditions to exist in the fire rooms which would cause a disastrous explosion. The boilers were comparatively new, of good design, and built by a firm which has a reputation for good work. When in use for auxiliary purposes they would be worked at a much lower pressure than when supplying steam for the main engines, in which the initial pressure was about 135 pounds. All the boilers would likely be under steam at the time, too, with fires banked, as no warship captain would be likely to be caught in a foreign port, under the circumstances, without steam on. Even granting a boiler explosion possible, the rupture would likely occur at the longitudinal seams, and in this case the cross bunkers would have to be shattered before even the after bulkhead of the forward magazine would be reached. It has been suggested, too, that a bomb containing high explosives might have been hidden in the coal by some fanatic, and when this was thrown into the furnace the explosion followed. Here again the protection which the cross bunkers afforded would have to be considered.

Spontaneous combustion finds many supporters as the prime cause of the disaster. It is of course a possible cause of disaster which has to be taken account of, but consideration of the conditions which prevailed on the Maine are quite

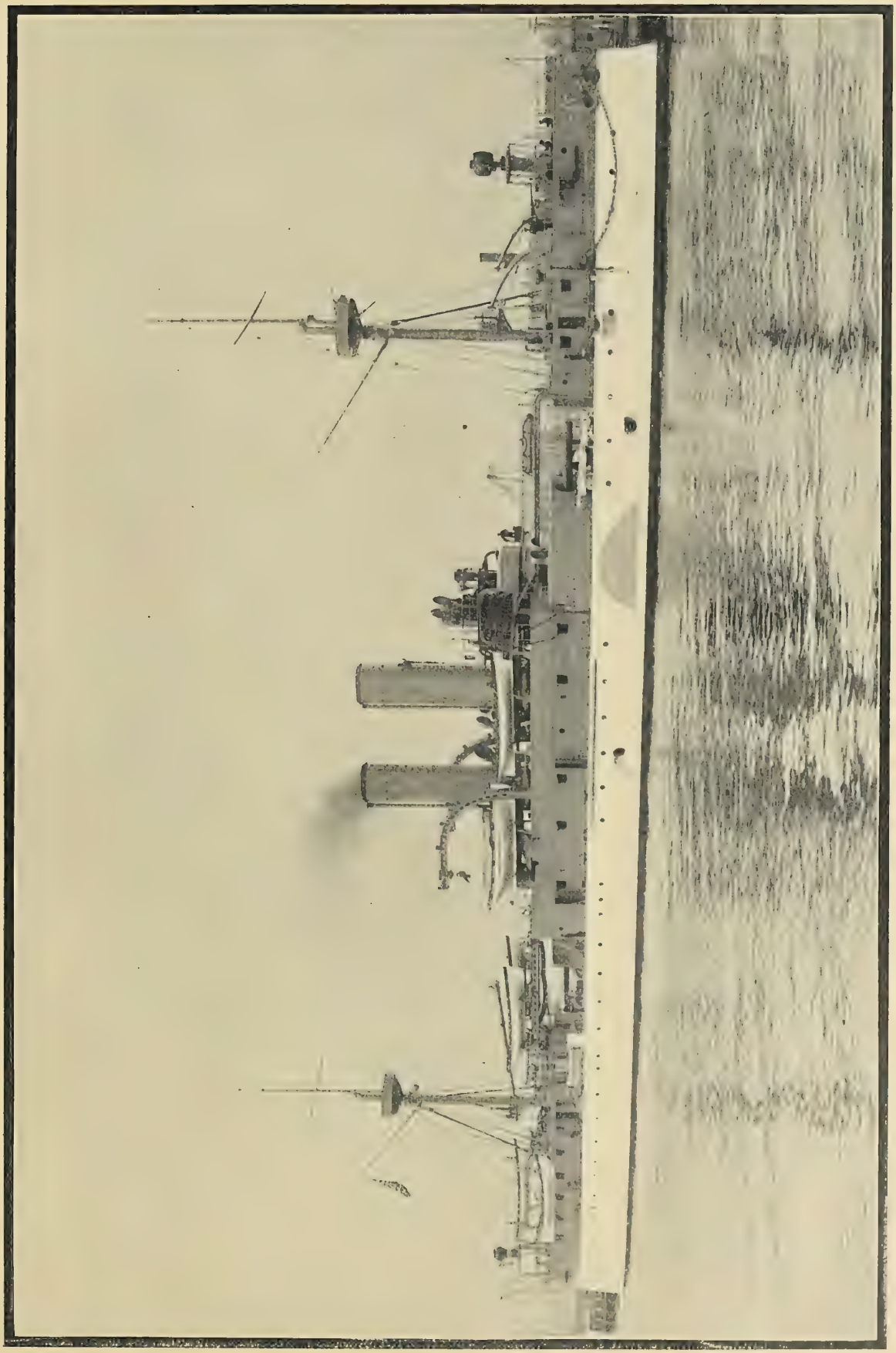


CROSS SECTION OF THE "MAINE" AT THE POINT WHERE THE EXPLOSION IS SUPPOSED TO HAVE OCCURRED.

against this theory. Before her trip to Cuba, the Maine had been using West Virginia bituminous coal, but when she received her sailing orders at Key West, her bunkers are stated to have been filled with hard, or anthracite coal. The total coal capacity of the Maine was 825 tons, which was distributed in twenty coal compartments, principally located along the sides, as protection for the ship's vitals. The bunkers were filled through trunks leading down from the main deck, and escape trunks were arranged to connect the bunkers with the fire room over the boilers, so that the trimmers could pass to and fro when coaling. It will be seen that each bunker was not of great capacity; the cross bunkers, which



WRECK OF THE BATTLESHIP MAINE IN HAVANA HARBOR AS IT APPEARED THE DAY AFTER THE EXPLOSION.



THE LATE U. S. SECOND-CLASS BATTLESHIP MAINE AT THE NAVY YARD, NEW YORK, BEFORE SHE WAS ORDERED SOUTH.

were interposed between the forward boilers and the forward magazine, would contain only about 20 tons each, when filled. Even supposing the Maine had a good many tons of bituminous coal in her bunkers at the time she took in the anthracite coal at Key West, the fact that the hard coal was loaded on top of the soft would tend to bury the latter in the bottom of the bunkers and keep from it whatever air supply might get in. It is not likely, however, that any considerable amount of fresh air passed through the bunkers, and so the little soft coal on board would have small chance of seizing enough oxygen to become dangerous. Again, the Maine had a tendency to trim by the head when loaded, and for this reason the coal in the forward bunkers was invariably used first, so if even these were not emptied they would be under the constant observation of the passers. When coal is heating the condition is made known by a peculiar smell which would not be mistaken by any one accustomed to handling fuel. The cases of spontaneous ignition of coal on the Cruisers Cincinnati and New York, in the former case causing the shell racks in one magazine to char, have been cited. This, however, gives very little guidance in the solution of the Maine disaster. The fires mentioned occurred in bunkers containing soft coal exclusively, and the attendant circumstances and conditions would probably be found to be quite dissimilar, upon examination.

A more plausible theory of origin of the disaster, connecting it with the bunkers, would be that the first explosion was caused by an explosive mixture of inflammable gas and air which had come in contact with a naked light. Certain grades of coal emit an inflammable gas for a considerable time after being mined. This would be given off in increased quantities when the coal was broken, a state which the conditions favored—due to the weight of the fresh supply of hard coal shot into the bunkers. The temperature in the bunkers would likely assist this process, also, as the fire rooms were decidedly warm, and the area of exposed bunker wall considerable. Such a temperature would be too low for the generation of inflammable gas from the coal, but would aid the emission of the gas contained in the coal. A mixture in the proportions, of anywhere from 9 to 15 to 1 of air, would produce a violent explosion upon the application of a naked light. The opening of a bunker lid, or the entrance of a coal passer into a recently opened bunker with a torch might give the needed ignition. These, however, are mere conjectures based on the assumption that a certain kind of coal was present in appreciable quantity.

It is possible that a scientific solution of this mystery may never be reached. If an outer explosion was followed by one from the inside, such as the explosion of the main battery ammunition, the hull conditions would be capable of almost any interpretation. There would likely be some distortion, too, of the frames and plating, by reason of the sinking of the ship at such an inclination that the bow probably touched bottom an appreciable time before the stern came to rest. Even the most careful and dispassionate inquiry may lead up to a wrong conclusion, as was the case in the investigation of the blowing up of H. M. S. Doterel, an account of which will be found on page 13.

Technical Description of the "Maine."

The Maine was originally officially known as a twin screw armored cruiser. She was designed by the Bureau of Construction and Repair of the Navy Department, of which Commodore Hichborn is the Chief, and was built at the New York Navy Yard. As originally drawn, the plans for this ship provided for a considerable spread of canvas on three masts, barque rig. These plans were modified later, however, with the intention of placing the vessel in the battleship class, and thus among other changes, what would have been the main mast was dispensed with and the fore and mizzen masts altered to their military form. This accounts for the great distance apart of the masts which the Maine carried, a feature of design which invariably caused comment. The keel was laid October 11, 1888, and the hull was launched November 18, 1890. In the scale drawings, reproduced in the inset supplement with this issue, the general arrangement and compartment plans are clearly laid out. The hull was of mild steel, divided into 198 watertight compartments, and with a double bottom extending 196 feet (about the distance between the masts) and carried up to the shelf for the armor belt 4 ft. below the water line. In the wake of the double bottom and under the machinery spaces the hull was stiffened by additional longitudinals. The outside keel plate was 5-8 in. thick, inner plate 1-2 in. and the vertical keel 1-2 in.; the outer bottom plating was 1-2 in. thick and the inner bottom 5-16 in. The general dimensions were: Length, between perpendiculars, 310 ft.; over all, 324 ft. 4 in.; breadth, molded, 56 ft. 10 in.; draught, mean, 21 ft. 6 in.; area, immersed midship section, 1,077 sq. ft.; displacement at mean draught, 6,650 tons; tons per inch, 32.32; coefficient of midship section, 0.878 ft.; area of load water line plane, 13,500 sq. ft.; wetted surface, 23,770 sq. ft.

The plan of the hold in the inset supplement shows the exact location of the magazines, which were kept as compactly as possible over the keel line, the main magazines being protected by coal belts. Aft of the collision bulkhead for a distance of 39 ft. there were compartments for wet and dry stores, and then the forward bulk head of the main magazine, extending a distance of 48 ft. In the forward end of this magazine ammunition for the 6 in. guns was stored in a space 12 ft. long and 20 ft. wide, separated from the 6 pounder magazine by a watertight bulk-

head. The 6-pounder magazine containing fixed ammunition was about the same size. These two divisions of the magazine were forward of the armor belt, though of course under the protective deck, and interposed between them and the sides were fresh water tanks and paymaster's storerooms. Abaft the 6-pounder magazine came the 10 in. magazine on the starboard side of the keel line, and the 10 in. shell room and 6 in. magazine to port. This was isolated by watertight bulkheads and extended 24 ft. fore and aft, and 29 ft. athwartships. Wing bunkers were interposed between this portion of the magazine and the sides, and these extended inboard between the magazine walls and the boilers a distance of 8 ft., leaving about 13 ft. of the magazine bulkhead exposed in the fire room. Abaft this magazine the boiler room occupied 87 ft., and then came another magazine, containing 10 in. and 6 in. ammunition, divided by a passage fore and aft leading from the stoke hold to the engine room. The engine room occupied the full width of the ship and extended 35 ft. fore and aft. In the space between the shaft alleys, the after engine room bulkhead and the bulkhead at the outboard shaft bearings, the magazine containing the torpedo heads, small arms ammunition and 6 in. reserve ammunition was located.

The platform deck extended forward and abaft the machinery spaces, and in the space between the boiler and engine rooms. None of the magazines came above this deck, which was situated about 10 ft. below the water line. In the forward end the storeroom and fresh water tanks came up through this deck. The space over the forward magazine was used for storerooms and for the trunks leading up from the magazines. Over the 10 in. magazine was the hydraulic pump room for the forward turret and electrical storeroom. In the deck space between the boilers and engines there were also hydraulic pumps for the after turret, also distilling apparatus, ordnance stores and the necessary trunks and hoists connecting with the magazine below. Abaft the engines, over the magazine, were engineer's, marine and medical and paymaster's stores, and in the center the steering engine room. Here also were entrances to the wing passages which extended along both sides, between the armor belt backing and the bunkers, and which were covered by the protective deck, affording safe communication between the ends of the ship.

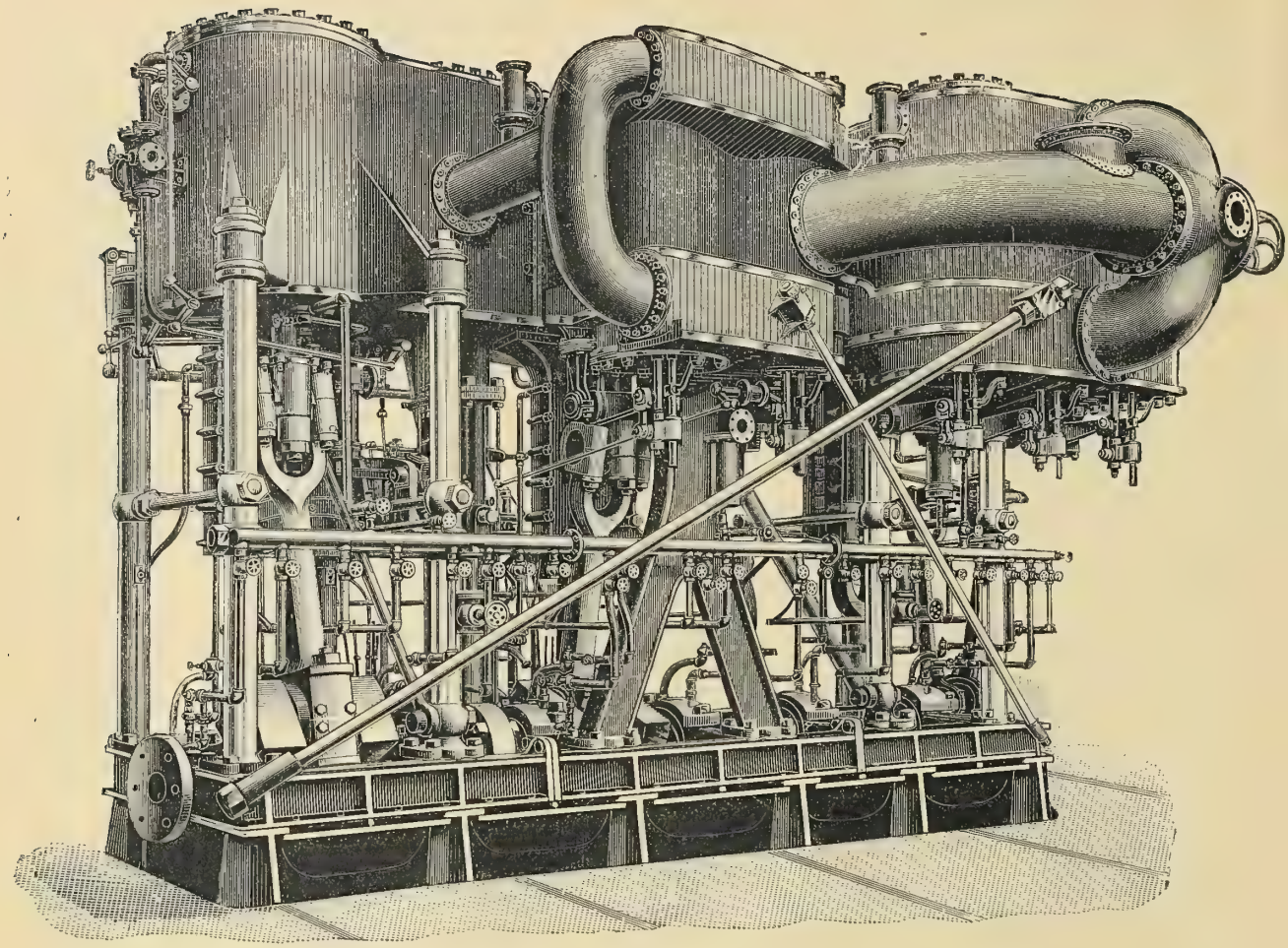
On the protective deck, the forward end of the ship up to the end of the armor belt was taken up with storerooms and chain lockers. Inside the citadel formed by the armor and over the hydraulic pump room, which in turn was over the 10 in. magazine, there was an ammunition passing room in which the magazine trunk hatches were placed. On the starboard side under the forward turret there was a loading room, which is clearly shown in the cross section at frame 24, which we here publish. Between this loading room and the port forward wing bunker came the dynamo room. Over the center line and between the dynamo room and the boiler room, and protected by the inboard bunkers before referred to the central station was fitted. This was immediately under the conning tower, with which it was connected by an armor tube. In this station connection was made between the various electrical and other signal apparatus in the conning tower and the various points throughout the ship where orders or communications were needed. Between the boiler and engine rooms on this deck the steam mains were carried, and on the port side below the after turret there was a loading room, and hatches opening into the magazine below. The after end on this deck, abaft the armor belt, was used for stores; both ends were protected by belts of cellulose which in fact formed a continuation here of the armor belt, fore and aft. Passages on this deck also extended the length of the armor belt, fore and aft.

On the berth deck the living quarters were located. Forward and amidships were the crew spaces, and on the port side abreast of the forward turret the sick bay. On this deck there were four torpedo tubes. One was situated on the starboard side just forward of the turret. Two tubes were placed on opposite sides about abreast of the smoke pipes, and the fourth tube was in position abaft the turret on the port side. In the center of the ship on the starboard side there was an engineer's workshop. Variously disposed on this deck were the various officer's mess rooms, ward room and officers' state rooms.

On the main deck the batteries of heavy guns were carried. Here also was the windlass and anchor gear forward, within the superstructure. In the superstructure amidships there was the crew's mess room, galley, signal room and armory. In the after superstructure there was a large saloon and captain's cabin and executive officers' offices.

On the superstructure deck forward a powerful search light was fixed at a considerable elevation. Here also the various boats were carried. The conning tower was situated just in front of the forward funnel, and above this there was a chart house surmounted by a rail and fitted with compasses and indicators, so that it could be used as a platform from which to navigate the vessel.

In detail the armor consisted of a belt of Harveyized steel extending about 180 ft. amidships and 3 ft. above and 4 ft. below the water line. It was 12 in. thick from the top to a space of 12 in. below the water line, and from there it tapered to 7 in. at the armor shelf. It was backed by 8 in. of teak, behind which were two thicknesses of 1-2 in. plating very thoroughly stiffened by angle bars and plates. At the forward end of the armor belt there was an athwartship 6 in. steel bulkhead with wood back. This inclosed space was covered with a protective deck of two layers of 1 in. steel, which sloped down below the water



FRONT VIEW OF THE TRIPLE-EXPANSION ENGINES OF THE "MAINE."

line at the after end of the side belt. The turrets on the main deck were of 8 in. Harveyized steel armor, strongly backed, and the revolving mechanism and gun platforms were protected by a fixed barbette of mild steel 12 in. thick. The conning tower, elliptical in shape, was 10 in. thick, connected with the central station below by a 4 1-2 in. armored steel tube.

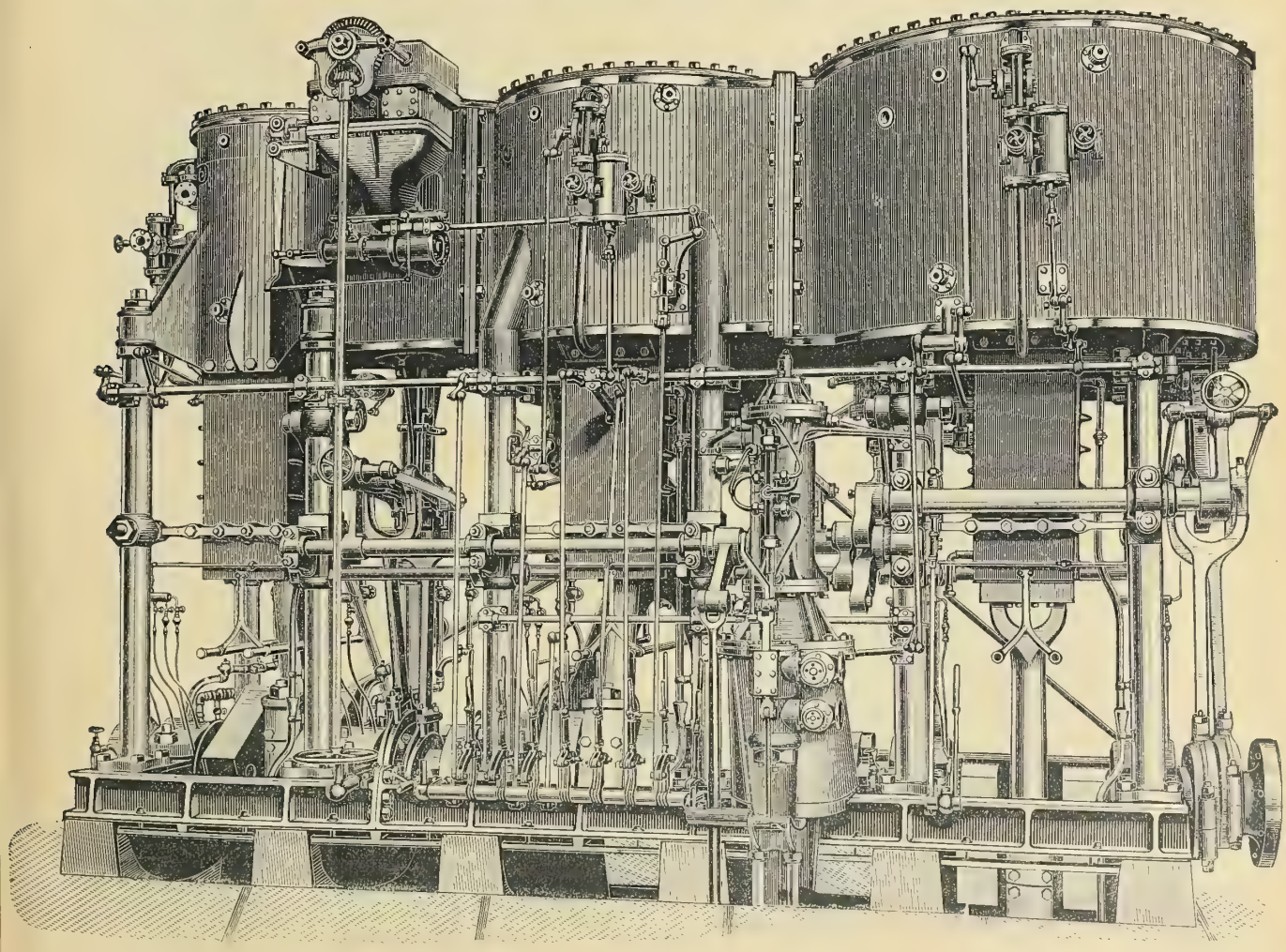
The armament consisted of four 10 in. breech loading rifles, two in each turret, also six 6 in. breech loading rifles, two placed in the forward superstructure, and two in a similar position aft, and one on each side amidships. These guns were operated by hand gear and protected by 2 in. steel shields.

The 6 in. guns forward and aft could be fired parallel with the keel line, or all could be fired broadside. The 10 in. guns could also be fired ahead or astern according to their respective positions. The guns in each turret could also be fired across the decks through an angle of about 60 deg. With all the guns trained for broadside fire a total weight of projectile of 4,800 pounds could be obtained at one discharge. The secondary battery included seven 6-pounder, eight 1-pounder rapid fire, and four Gatling guns. Four Whitehead torpedo tubes were fitted with eight torpedoes.

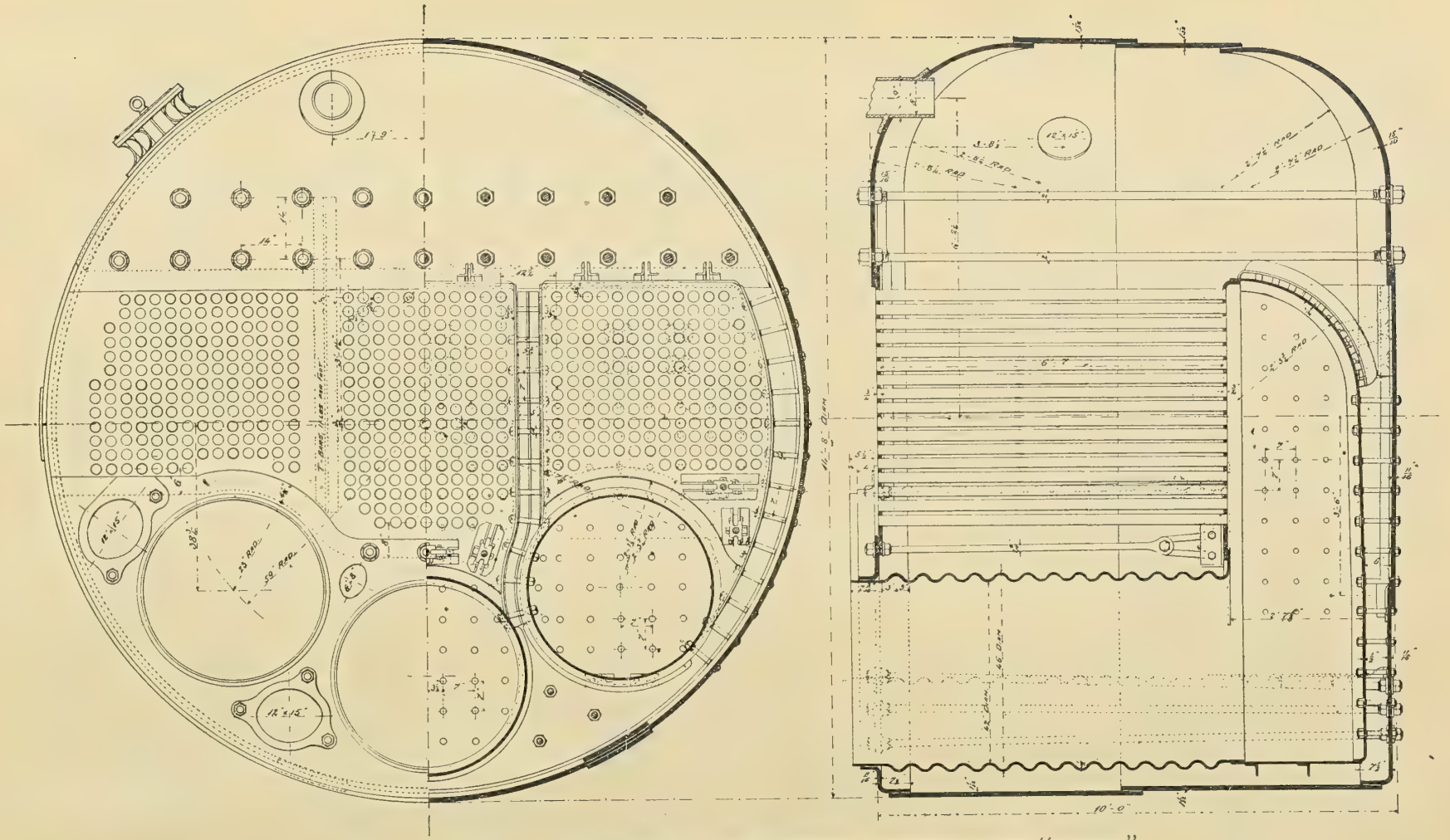
Machinery Equipment of the "Maine."

The machinery of the Maine was built by the Quintard Iron Works, New York, from designs prepared under the supervision of Commodore Melville, Chief of the Bureau of Steam Engineering. There were two sets of triple-expansion engines, exact engravings of which both front and back, we present on this and the opposite page. They were arranged in separate engine rooms, divided by a fore and aft bulkhead, which reached up to the steel protective deck. The cylinders were 35 1-2 in., 57 in. and 88 in. dia., and 36 in. stroke. Steel was used for the bedplates which were in three sections bolted together. The frames were hollow forged steel columns, with the exception of the front column of the I. P. cylinder, which, in each engine, consisted of a single inverted Y steel column. Horizontal and diagonal steel braces were used for staying the columns. The cylinders were placed in order from forward aft, L. P., I. P. and H. P., and the piping was so

arranged that the L. P. cylinders could be disconnected, and with the H. P. and I. P. only in use the engines worked compound. All the cylinders were jacketed. Piston valves of the single ported type were used throughout, one for the H. P., two for the I. P., and three for the L. P. cylinders, all of 22 in. dia. Stephenson link motion with double bar links was used for all, the H. P. valves being worked direct and the I. P. and L. P. valves by rock shafts. Balancing pistons were provided for the H. P. valves. Single slide crossheads were used, the slippers working in composition guides 22 in. long and 20 in. wide. The pistons were of composition, with rods of forged steel, 6 1-4 in. dia., the bottom end of each rod forming a crosshead, fitted with an adjustable brass and composition cap. Connecting rods were also steel forgings, each 6 ft. long between centers, with forked crosshead ends, and the usual through bolted crank ends. The crank shafts were in three interchangeable sections, with forged couplings. Two bearings were provided for each section. They were 13 in. dia. and 23 ft. 3 in. long, with a 4 in. hole, and with seatings for the eccentric sheaves 13 1-2 in. dia. The cranks were set 120 deg. apart, in regular sequence, with webs 17 1-2 in. wide and 9 in. thick, and with pins 14 in. dia., 14 in. long and with 4 in. through holes. Steam reversing gear with hydraulic controlling cylinders was fitted for each engine. All the main brasses were lined with Parson's white metal and very complete arrangements for lubrication were in place. Distributing tanks were fitted on the sides of the cylinders, supplied with oil by a pump from the main tanks. The crank pins were also provided with centrifugal oil feeding devices, and sight feed cups were attached to the live steam pipes on the main engines and auxiliaries. The main stop valves could be worked either from the engine room or the berth deck, and screw stop valves were also arranged so that both engines could be controlled, if necessary from either engine room. The thrust shafts were 12 ft. 5 in. long, 12 3-4 in. dia., and with 6 in. through holes. Each was fitted with 11 collars 17 1-4 in. outside dia., 2 in. deep, and 1 5-8 in. thick, spaced 2 1-8 in., giving a thrust surface of about 1,000 sq. in. The forward propeller shafts were 21 ft. long, 13 3-8 in.



BACK VIEW OF THE TRIPLE-EXPANSION ENGINES OF THE "MAINE."



SECTIONAL DRAWINGS OF THE SINGLE-ENDED SCOTCH BOILERS OF THE "MAINE."

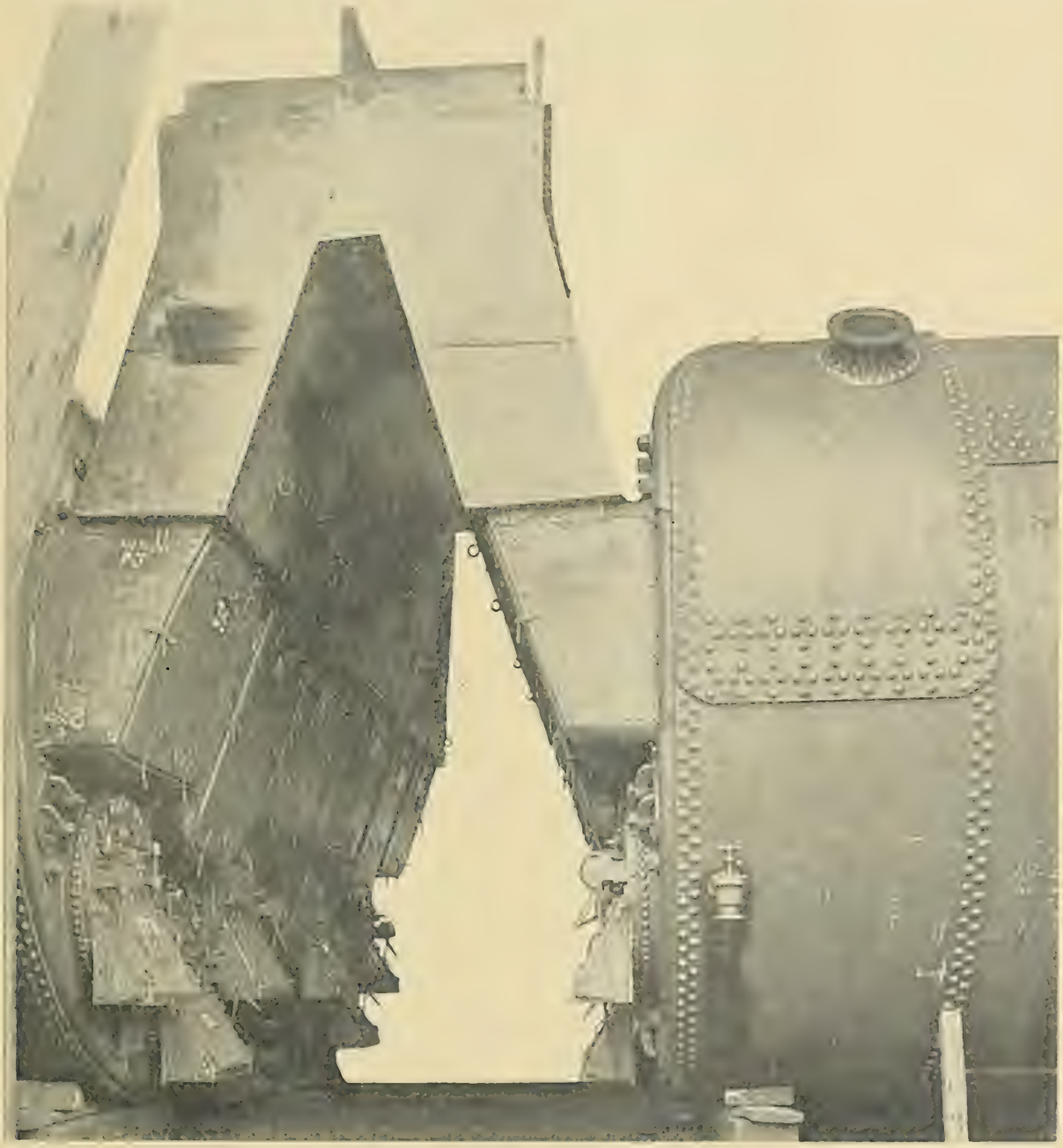
dia., with a 6 3-4 in. hole, and the after shafts 27 ft. long, 13 1-4 in. dia., with a 6 1-2 in. hole. Where they passed through the stern tubes and stern brackets, they were cased in composition 3-4 in. thick. The total length of shaft for each engine was 84 ft. 3 in.

Manganese bronze was used for the propellers, which were four bladed, true -screws with adjustable blades, spherical hubs, and conical tail pieces covering the tap bolt heads. The propellers were 14 ft. 6 1-2 in. dia., and normally 16 ft. pitch. The distance of tail shaft centers from bottom of keel was 8 ft. 1 in., and immersion of tip of blades at normal draught 6 ft. 2 in.

Composition was used for the condenser shells of which there was one in each engine room. They were 10 ft. 5 in. long, 6 ft. 6 in. dia., and each contained 5,141 tubes, giving a total cool-

ing surface for each of 7,000 sq. ft., or a ratio of cooling surface to total heating surface of 1 to 1.35. The circulating water was passed through the tubes. Each condenser was arranged so that it could be used as an auxiliary condenser, using an auxiliary centrifugal circulating pump. Independent main combined air and circulating pumps were fitted. The air pumps were double, vertical, single-acting, connected to a horizontal double-acting circulating pump, all worked by a horizontal tandem compound engine, with cylinders 12 in. and 24 in., and a common stroke for steam and water cylinders of 18.5 in. The air pump cylinders were 30 in. dia., and circulating pump cylinders 31 in. dia.

There were eight single ended Scotch boilers of the Navy pattern, in two groups of four each, placed in separate watertight compartments. The boiler fronts were inboard, and they were fired athwartships. Detail drawings which are here reproduced (page 10) clearly show the design. The uptakes connected each group of boilers with one smoke pipe, internal division plates being used to keep the gases from each boiler separate. Each boiler was 14 ft. 8 in. dia. and 10 ft. long, with three corrugated furnaces



FORWARD FIREROOM BOILERS OF THE "MAINE" SET UP IN BUILDERS' YARD.

42 in. dia. They were built for a working pressure of 135 pounds, and were tested to 225 pounds by the application of heat to water. The grates were 6 ft. 10 in. long. Each boiler was fitted with 401 ordinary tubes, and 118 stay tubes, 2 1-4 in. outside dia. The steam room in each boiler when the water was 6 in. above the tubes was 374 cu. ft., and the contained water 40,828 pounds. There was an 8 in. admiralty type, self closing stop valve on each boiler, and auxiliary stop valves 5 in. dia. were placed on each of the two forward and two after boilers. Two 4 1-2 in. spring safety valves were fitted to each boiler. For the eight boilers the total grate surface was 573.84 sq. ft.; total tube heating surface 16,101.11 sq. ft., plate surface 2,914.23 sq. ft., or a total of all heating surface of 19,015.34 sq. ft. The ratio of total heating surface to grate surface was 33.137 to 1. The smoke stacks were 75 ft. above the lower grates, and the area of each was 40.27 sq. ft. In the reproduction of the photograph of one set of boilers set up in the builder's yard the arrangement of the fittings will be observed.

Forced draft on the closed ash pit system was installed, with Sturtevant blowers discharging into proper ducts fitted with dampers. These could be regulated by hand, and they also automatically cut off the draft when a furnace door was opened. The blowers were arranged to take their supply from the stoke hold, creating an inrush of fresh air through the gratings into the fire room. Two blowers were fitted, each capable of discharging 25,000 cu. ft. of air per minute when running at 550 revolutions. They were driven direct by Sturtevant engines.

A considerable number of auxiliaries were fitted in the vessel. In each fire room there were two vertical duplex double-acting feed pumps, one for the main and one for the auxiliary feed. The auxiliary pumps were arranged for a variety of uses, including that of fire pumps. The pumps had steam cylinders 10 in. dia. and 6 in. water ends, and 12 in. stroke. A feed tank containing 550 gallons was fitted in each engine room, with a filter arrangement through which the feed water was passed. Other pumps were fitted for bilges, drains and for the engine room water pipes, and for fire purposes. A jacking engine was geared to each main engine. There were also ventilating fans for the engine rooms and crew spaces on the berth deck. In the after part of the ship, below the water line, a combined steam and hand steering gear was placed, and this could be variously operated from the conning tower, flying bridge, pilot house, superstructure deck, or from the steering engine room. The powerful windlass and capstan on the main and superstructure decks was also operated by steam, various winches, workshop engine, and distilling apparatus also made demands on the steam supply.

The hydraulic plant was extensive, including apparatus for turning the turrets, loading and working the guns, and for hoisting ammunition. The position of these sets of machinery, one for each turret has already been indicated. By a duplication of the pressure piping, each of these plants could be used to operate both turrets. In each set there were two horizontal duplex pumps, connected with a steam accumulator, with a capacity of 550 gallons a minute at a pressure of 600 pounds, the pumps taking steam at 100 pounds pressure. The turning engines were of compact design of the single acting oscillating cylinder type, geared to the circular turret turning rack. An air compresser was also included in the machinery outfit for supplying air for the torpedoes gear.

The lighting plant consisted of two generating sets, with four pole compound wound dynamos driven direct by vertical engines, with cylinders 13 1-2 in. by 6 in. stroke. The dynamos developed 400 amperes at 80 volts, and furnished current for 500 16-candle power incandescent lamps, four searchlights of 60,000 candle power, and two of 80,000 candle power, and for a small motor driving a fan for ventilating the dynamo room.

Trial Trips of the "Maine."

The trial trip of the Maine was run in October, 1894, in Long Island Sound. The object was to determine the horse power, and the run was for four consecutive hours. There was a strong head wind and sea, and the average speed was nearly 16 knots, though allowing for wind and tide, the speed figured out 17.45 knots. This trial was very successful, so far as the behavior of the ship and the working of the machinery were concerned. The trial draught forward was 18 ft. and aft 19 ft., and the displacement 5,500 tons. With a boiler pressure of 145 pounds the engines made 123 turns. Forced draught was used, the air pressure in the ash pits reaching 1.074 in. The indicated horse power of the starboard engine was 4,696.95 and of the port engine 4,474.50, or 9,171.45 for both engines, and for all machinery, including pumps, blowers and auxiliaries, 9,292 indicated horse power. This showed 2.0462 sq. ft. of heating surface per I. H. P. and 1.5087 sq. ft. of cooling surface, and 16.1938 indicated horse power of all machinery in operation per sq. ft. of grate surface. The indicated horse power per ton of propelling machinery, including boilers and contained water, was 14.18. Pocahontas coal was used, and the consumption was 35.327 pounds per sq. ft. of grate surface, and per indicated horse power of all machinery, 2.1815 lbs.

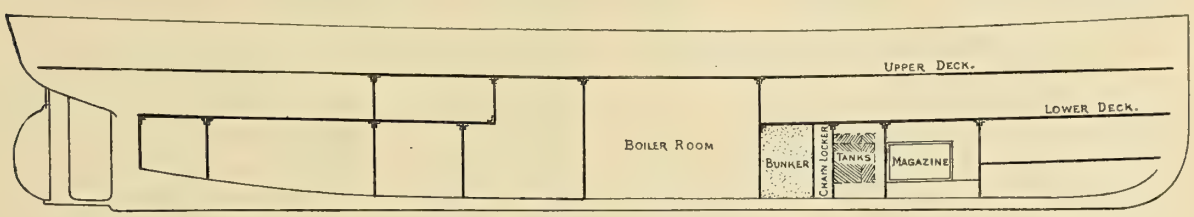
When in commission, and using Pocahontas coal, a coal trial of the Maine at cruising speed was made. Her bottom was clean and the weather during the trial, which lasted almost one day, was fine. Using half her boiler power, the engines making 74 turns, developed 1,697 horse power, and a speed a small fraction in excess of 11 knots was maintained. The horse power coal consumption was 2.22 pounds and the consumption for all purposes was 5.84 pounds per knot.

Fatal Explosions on British Warships.

In the history of naval disasters, leaving out of consideration those due to intentional submarine explosions, or those in which accidental gun explosions occurred, there are two cases which are of special interest at this time. It is not so much that they parallel the Maine disaster as to the origin of the explosion but to similarity in other respects that a recollection of them is timely. The disasters referred to both occurred to British naval vessels; one the explosion of a main boiler on H. M. S. Thunderer, in July, 1876, and the other the blowing up of H. M. S. Doterel, in April, 1881.

The Thunderer in her day was one of the most powerful battleships in the British Navy. She is a double-turreted ship, 285 ft. long, 62 ft. beam and of 9,190 tons. Her hull was constructed at the Pembroke Royal Dock Yard, and was launched in 1872. Her machinery was built by the famous English firm of Humphrey & Tennant, and consisted of low-pressure twin screw horizontal engines of 5,600 H. P., and eight rectangular wet-bottom boilers. These were set in two fire rooms, much the same style as the boilers of the Maine, and each boiler measured 15 ft. 3 in. in a fore and aft direction, 13 ft. high, and 10 ft. 6 in. athwartships. Each had four furnaces. They were built to work at 30 pounds pressure. After the ship was completed as to her machinery, there was for some reason a considerable delay in getting her ready for sea. It was in July, 1876, that she went to sea on a contractor's trial. She had started a full speed run, when those on deck were startled by a noise, which was afterwards described as like the sound of an explosion of a mining charge, or torpedo under water. Clouds of steam immediately came up through the gratings. An investigation showed that one of the starboard boilers had burst, the steam space in the front of the boiler having been blown out, shearing the rivets and tearing the plates in places. Fifteen men were taken out of the stoke hold, dead, and of those injured, twenty-four subsequently died. An inquest was held, and exhaustive investigations made by the ablest engineers in England to discover the cause of the accident. The Coroner's jury found that the explosion was caused by the sticking of the safety valves, due to contraction of their seats. There were two valves on the boiler, of an old form, loaded with weights. In the evidence it was shown that by some unaccountable error the stop valve of the boiler had either not been opened at all, or had been closed during the run. The steam gauge was proved also to have been defective, and at the time of the explosion did not register more than 18 pounds, whereas experts believed the boiler was not ruptured until 100 pounds was reached.

The loss of the British cruiser Doterel, with 8 officers and 133 men, on April 26, 1881, caused a tremendous sensation in naval circles. She was a new vessel, built of wood, with iron frames, 170 ft. long, 36 ft. beam, and 14 1-2 ft. draught, and was an unusually strong vessel. She was barque rigged, depending chiefly on sail for propulsion, though she had a single screw, with compound engines of about 1,000 horse power. She had three boilers 7 ft. 9 in. dia., fitted in a fore and aft position on the keel line. When she blew up she was at Sandy Point, in the Straits of Magellan. She had a crew of about 140 men, and considering the few who survived, the terribly fatal character of the mishap can be understood. The survivors reported that there were two distinct shocks, following each other at an interval of about 20 seconds, much the same as occurred on the Maine. The first explosion was apparently not so severe as the second, for after this she sank almost instantly in 50 ft. of water, there being no time even to launch a boat. As in the case of the Maine, also, other vessels lying near were not injured in the least. The explosions occurred forward, the first on the starboard side, and the second the magazine, the position of which is here indicated in the sketch. It will be noted that the fore magazine was separated from the boiler room by a coal bunker, chain locker and water tanks, each of which in turn was separated by iron bulkheads extending to the upper deck. The tops of the boilers came above the lower deck, in which were the magazine hatches. The bunker capacity was about 140 tons of coal, and as she used sails mostly, this was likely to be filled with one supply of coal for a considerable time.



PROFILE OF H. M. S. DOTEREL, SHOWING LOCATION OF MAGAZINE, FORWARD.

Several theories were immediately put forward as to the cause of the disaster. Some asserted that a torpedo had exploded in the magazine, others that she had fouled a torpedo laid down during the then late Chilian-Peruvian war, and again others, that one of her boilers had exploded and set off the magazine. Many contended that a Fenian emissary had introduced a bomb into the coal supply.

In the inquiry which followed it was ascertained that she was about to take on coal, and that the bunker lids had been raised, and that these were adjacent to the galley in which a fire was burning. After a lengthy consideration of the case the Board of Inquiry decided that the first explosion was caused by an explosion of bunker gas, and that this set off the forward magazine.

Every one was satisfied with this explanation, until in November of the same year a mysterious explosion occurred on board H. M. S. Triumph. This occurred in the paint room, while she was lying at Coquimbo, and caused the death of two of the crew, and more or less severe injuries to eight others. Captain A. H. Markham in his report after the disaster expressed his opinion that it was due to the storage of a keg of xerotine siccative in the glory hold, under the paint room. This is a high sounding classical name for a composition used by painters, and commonly known as "patent driers." It is composed largely of benzoline, and as its name would indicate is put in paint to make the coat dry quickly. It possesses the property also of giving off highly explosive gas or vapor which only needs the contact of a naked light to produce disastrous results, which are only limited by the amount of vapor present and the strength of the enclosing structure. The Court of Inquiry, after an exhaustive examination, confirmed the opinion of Capt. Markham as to the cause of the Triumph explosion.

This at once recalled the destruction of the Doterel, and some of the survivors of that terrible affair came forward and testified that a large jar containing xerotine siccative had been kept on the Doterel in the vicinity of the magazine. The jar had leaked badly, and a considerable quantity of the drier had escaped before the leak was discovered and the jar thrown overboard. Thus the real cause of the blowing up of the Doterel was discovered in an accidental way.

These accidents and others of a less disastrous character caused the British Admiralty to commence a long series of investigations into the subject of explosions on war vessels. Orders were also issued to get rid of all the xerotine siccative on vessels, and that no new compounds should be issued by any departments until they had been chemically examined and reported upon as to their explosive qualities. The investigations pursued by the committee of experts resulted in a recommendation that the ventilation of coal bunkers in vessels should be kept separate from the system used for ventilating other portions of the vessel, and that it should be continuous. This necessitated not only means for admitting currents of air, but means of escape for any gases that might be evolved.

On the committee Engineers, Chemists and Constructors, possessed of the very highest scientific attainments, were included. Many practical tests were made.

Concerning Naval Discipline.

When the news of the Maine disaster was first cabled abroad it called forth criticisms upon the American Navy, in some quarters, which were as extremely ridiculous in the one direction as the bombastic blatherskite printed in many home papers was in the other. The St. James Gazette of London, was inclined to the belief that the loss of the ship was caused by an explosion in the magazine, adding:

It remains, however, to be explained how a magazine carefully guarded could be fired. As bearing on this, however, it must be borne in mind that the discipline on American war ships is to English ideas rather lax.

Apparently the St. James Gazette has forgotten the blowing up of H. M. S. Doterel, and the evidence which was given at the subsequent investigations? W. B. Baird the carpenter of the Doterel, testifying before the inquiry committee at Portsmouth dockyard, was asked, with reference to the leakage of xerotine siccative in the masthole forward, and which occasioned the explosion:

Q.—Where did you mess on board the Doterel?
A.—In the fore compartment.
Q.—Was the smell very strong, so that all the men would notice it?
A.—It was very strong, as soon as you came on the mess deck ladder, and all of them were talking about it the night before. The smell was awful.

Yet with all the men "talking about it" the officers do not seem to have had anything to say and it was left to the plumber's mate to throw overboard the leaking jar of the explosive, too late, however, to prevent the immediately following explosion. Again in the inquiry into the cause of the fatal explosion, caused by xerotine siccative, on board H. M. S. Triumph, at Coquimbo, in the same year, Mr. Goodwin the carpenter in his examination was asked by his commander, Captain A. H. Markham:

Q.—Were the orders of the ship relative to the use of naked lights in the paint room to your personal knowledge strictly carried out?
A.—On all occasions *strictly enforced but not carried out.* On one or two occasions the painter has been punished for having a naked light in the paint room.

Captain Markham himself in his observations concerning the explosion wrote:

I deeply regret that for some *incomprehensible reason* we, on board, were not in possession of more explicit information regarding the exceedingly dangerous and explosive nature of this composition (xerotive siccative) before it was authorized to be issued to us as ship's stores. * * * No one but the painter, or those acting under his orders, has access to the paint room during the day, and strict orders were, and are, in force regarding the use of naked lights in that particular compartment. In fact, the painter himself had been punished for carelessness in using a naked light in the paint room only a month ago.

Now if these facts are the results of "English ideas," and the statement of the St. James Gazette be true, surely the conditions on the Maine must have been awful! Probably the crew of H. M. S. Calliope could give our contemporary some pointers about discipline on vessels of the American navy.

Vessels of U. S. Navy on the Active List.

The Maine disaster has had the effect of increasing the interest of those engaged in maritime affairs in the strength and efficiency of the Navy. Most, if not all, of the vessels on the active list are known by name, but frequently the type of vessel is not so familiar and for this reason a statement of the chief characteristics of the seagoing ships of the Navy is of special importance, for information and ready reference. The following list is prepared from the latest official data, and includes all vessels built or building other than a few obsolete wooden steam and sailing vessels, which represent memories of the past rather than possibilities of the future. There are nearly a dozen such steam vessels and half a dozen sailing vessels, which are variously employed in work—such as receiving ships at various naval stations or training ships for the naval militia.

In the first, or battleship division of the Navy list, there are included the battleships Kearsarge, Kentucky and Illinois, under construction at the Newport News yard, the Alabama building at Cramps, and the Wisconsin at the Union Iron Works in San Francisco. The dates set for completion of these ships extend throughout the year 1899, but owing to the armor plate dispute between the Government and the steel makers, it is not probable that all will be in commission by 1900. The battleships now on the active list have all been put in commission in the years 1895 and 1896, so that they are quite modern in design, construction, and equipment, with the single and important exception of their main batteries. The Iowa alone is equipped with rapid-fire guns in her main batteries, though these are of medium caliber—six 4 in. rapid-fire guns. The rapid-fire guns on the other ships are contained in the secondary batteries, of the 6-pounder type. In this respect as in all others the armored cruisers Brooklyn and New York represent the highest type of fighting machines of their class, having main batteries well supplied with the rapid firing type of guns, and possessing great speed and endurance, with adequate armor protection. Several of the torpedo boats are not yet completed, but work on nearly all could be so hurried that they would be quickly ready for service.

In the division of Iron and Wooden Steam Vessels there are included several ships which, of course, would not be available for any offensive operations in time of war. The Michigan, for example, built in 1844, is probably the oldest iron steamer afloat, and is engaged in special service on the Great Lakes. These vessels must, however, be considered as additional to the fighting fleets, filling quite important services, and their counterpart can be found in the fleet of, probably, every naval power.

Armament and armor have not been gone into in this list, as this would introduce a mass of detail which would complicate the descriptions and defeat the purposes of ready reference. It may be taken for granted that the vessels in each division are equipped in these respects, in conformity with the practice usual in the class to which they belong.

Three torpedo-boat destroyers recently contracted for are included in the list, though, of course, these have not got beyond the preliminary stages of construction.

BATTLESHIPS.

Name.	Length	Beam.	Draft.	Displacement.	Speed.	I. H. P.
	ft. in.	ft. in.	ft. in.	Tons.	Knots.	
Indiana	348.0	69 3	24.0	10,288	15.547	9,738
Iowa	360.0	72.2½	24.0	11,410	16.	11,000
Maine	318.0	57.0	21.6	6,682	17.45	9,293
Massachusetts	348.0	69.3	24.0	10,2-8	16.21	10,403
Oregon	348.0	69.3	24.0	10,288	16.79	11,111
Texas	301.4	64.1	22.6	6,315	17.	8,000
Kearsarge	368.0	72.5	23.6	11,525	16.	10,000
Kentucky	368.0	72.5	23 6	11,525	16.	10,000
Illinois	368.0	72.5	23.6	11,525	16	10,000
Alabama	368.0	72.5	23.6	11,525	16	10,000
Wisconsin	368.0	72.5	23.6	11,525	16	10,000

ARMORED CRUISERS.

Name.	Length	Beam.	Draft.	Displacement.	Speed.	I. H. P.
	ft. in.	ft. in.	ft. in.	Tons.	Knots.	
Brooklyn	400.6	64. 8¼	24. 0	9,271	21.91	18,769
New York	380.6½	64.10	23.10	8,200	21.	17 401

ARMORED RAM.

Name.	Length	Beam.	Draft.	Displacement.	Speed.	I. H. P.
	ft. in.	ft. in.	ft. in.	Tons.	Knots.	
Katahdin	250.9	43.5	15.0	2,155	16.11	5,068

ARMORED DOUBLE TURRET MONITORS.

Name.	Length	Beam.	Draft.	Displacement.	Speed.	I. H. P.
	ft. in.	ft. in.	ft. in.	Tons.	Knots.	
Amphitrite	259.6	55.10	14. 6	3,990	10.5	1,600
Miantonomoh	259.6	55.10	14. 6	3,990	10.5	1,426
Monadnock	259.6	55.10	14. 6	3,990	12.0	3,000
Monterey	256.0	59. 0	14.10	4.084	13.6	5,244
Puritan	289.6	60. 1½	18. 0	6,060	12.4	3,700
Terror	259.6	55.10	14. 6	3,990	10.5	1,600

ARMORED SINGLE TURRET MONITORS (IRON).

Name.	Length	Beam.	Draft.	Displacement.	Speed.	I.H.P.
	ft. in.	ft. in.	ft. in.	Tons.	Knots.	
Ajax	225.0	43.8	13.6	2.100	5 to 6	340
Comanche	200.0	46.0	11.6	1,875	....	340
Canonicus	225.0	43.8	13.6	2,100	....	340
Catskill	200.0	46.0	11.6	1,875	....	340
Jason	200.0	46.0	11.6	1,875	....	340
Lehigh	200.0	46.0	11.6	1,875	....	340
Mahopac	225.0	43.8	13.6	2,100	....	340
Manhattan	225.0	43.8	13.6	2,100	....	340
Montauk	200.0	46.0	11.6	1,875	....	340
Nahant	200.0	46.0	11.6	1,875	...	340
Nantucket	200.0	46.0	11.6	1,875	....	340
Passaic	200.0	46.0	11.6	1,875	....	340
Wyandotte	225.0	43.8	13.6	2,100	....	340

UNARMORED STEEL VESSELS.

Name.	Length	Beam.	Draft.	Displacement.	Speed.	I.H.P.
	ft. in.	ft. in.	ft. in.	Tons.	Knots.	
PROTECTED CRUISERS—						
Atlanta	271 3	42.1¾	16.10	3,000	15.60	4,030
Baltimore	327.6	48.7½	19. 6	4,413	20.096	10.0 4
Boston	271.3	42.1¾	16.10	3,000	15.60	4.030
Charleston	312.7	46.2	18. 7	3,730	18.20	6,666
Chicago	325.0	48.2	19. 0	4,500	15.10	5,084
Cincinnati	300.0	42.0	18. 0	3,213	19.	10,000
Columbia	412.0	58.2¼	22. 6½	7,375	22.8	18,509
CRUISERS—						
Detroit	257.0	37.0	14. 7	2,089	18.71	5,227
Marblehead	257.0	37.0	14. 7	2,089	18.44	5,451
Montgomery	257.0	37.0	14. 7	2,089	19.05	5,580
PROTECTED CRUISERS—						
Minneapolis	412.0	58.2¼	22. 6½	7,375	23.073	20,862
Newark	310.0	49.2	18. 9	4,098	19.	8,869
Olympia	340.0	53.0⅝	21. 6	5,870	21.686	17,313
Philadelphia	327.6	48.7½	19. 2 ½	4,324	19.678	8,815
Raleigh	300.0	42.0	18. 0	3,213	19.	10,000
San Francisco	310.0	49.2	18. 9	4,098	19.525	9,913
GUNBOATS—						
Bennington	230.0	36.0	14. 0	1,710	17.5	3,436
Castine	204.0	32.1½	12. 0	1,177	16.032	2,199
Concord	230.0	36.0	14. 0	1,710	16.8	3,405
Helena	250.9	40.1⅜	9. 0	1,392	13.0	1,600
Machias	204.0	32.1½	12. 0	1,177	15.46	2,046
Nashville	220.0	38.3	11. 0	1,371	14.0	1,750
Petrel	176.3	31.0	11. 7	892	11.79	1,095
Wilmington	250.9	40.1⅜	9. 0	1,392	13.0	1,600
Yorktown	230.0	36.0	14. 0	1,710	16.14	3,392
COMPOSITE VESSELS—						
Annapolis	168.0	36.0	12. 0	1,000	12.	800
Vicksburg	168.0	36.0	12. 0	1,000	12.	800
Newport	168.0	36.0	12. 0	1,000	12.	800
Princeton	168.0	36.0	12. 0	1,000	12.	800
Wheeling	174.0	34.0	12. 0	1,000	12.	800
Marietta	174.0	34.0	12. 0	1,000	12.	800
SPECIAL CLASS—						
Bancroft	187.6	32.0	13. 4	976	14.37	1,213
Dolphin	240.0	32.0	14. 3	1,486	15.50	2,253
Vesuvius	252.4	26.6⅜	10. 7½	929	21.42	3,795
TORPEDO BOATS—						
Cushing	138.9	14.3	4.10⅜	105	22 5	1,720
Ericsson	149.7	15.6	4. 9	120	24.	1,800
Stiletto	88.6	11.0	3. 0	31	18.22	359
Foote	160.0	16.0¾	5. 0	142	24.5	2,000
Rodgers	160.0	16.0¼	5. 0	142	24.5	2,000
Winslow	160.0	16.0¾	5. 0	142	24.5	2,000
Porter	175.0	17.0	5. 6	....	27.5	....
Dupont	175 0	17.0	5. 6	....	27.5	....
Rowan	170.0	17.0	5. 6	182	26.	3,200
Submarine	85.3	11.6	....	168	8.	1,200
Dahlgren	147.0	16.4½	4. 7½	146.4	30½	4,200
T. A. M. Craven	147.0	16.4½	4. 7½	146 +	30½	4,200
Farragut (Destroyer)	210.0	20.4½	6. 0	273	30	5,600
Davis	146.0	15.3½	5. 4	128	22½	1,750
Fox	146.0	15.3½	5. 4	128	22½	1.750
Morris	147.0	15.6	4. 6	103	22½	1,750
Talbot	100.0	12.6	3. 6	46½	20.	850
Gwin	100.0	12.6	3. 6	46½	20.	850
Mackenzie	101.6	12.6	4. 3	65	20.	850
McKee	101.6	12.6	4. 3	65	20.	850

IRON AND WOODEN STEAM VESSELS.

Name.	Length	Beam.	Draft.	Displacement.	Speed.	I.H.P.
	ft. in.	ft. in.	ft. in.	Tons.	Knots.	
IRON—						
Alarm	158.6	28.0	10.6	800	10.	600
Alert	175.0	32.0	12.9	1,020	10.	365
Monocacy	255.0	35.0	9.0	1,370	11.2	850
Michigan	163.3	27.1½	9.0	685	10.5	305
Pinta	137.0	26.0	10.0	550	8.5	190
Ranger	175.0	32.0	12.9	1,020	10.	365
WOODEN—						
Adams	185.0	35.0	14.3	1,375	9.8	550
Alliance	185.0	35.0	14.3	1,375	9.98	668
Enterprise	185.0	35.0	14.3	1,375	11.4	790
Essex	185.0	35.0	14.3	1,375	10.4	505
Hartford	225.0	44.0	18.2	2,790	12.	2,000
Lancaster	235.8	46.0	19.2	3,250	9.6	733
Marion	216.0	37.0	16.6	1,900	11.25	753
Mohican	216.0	37.0	16.6	1,900	10.65	613
Thetis	166.0	30.3	18.0	1,250	7.55	490
Yantic	180.0	30.0	12.2	900	8.30	225

TORPEDO DESTROYERS RECENTLY CONTRACTED FOR.

Name.	Length	Beam.	Draft.	Displacement.	Speed.	I. H. P.
	ft. in.	ft. in.	ft. in.	Tons.	Knots.	
No. 19	231.4	22 0	7.3	340	30.	
No. 20	197.0	20.5	8.6	360	30.	
No. 21	206 9	19.0	8.0	265	30.	

WOODEN SAILING VESSELS.

Name.	Length	Beam.	Draft.	Displacement.	Speed.	I. H. P.
	ft. in.	ft. in.	ft. in.	Tons.	No En	gines.
Constellation	176.0	42.0	20.0	1,186		
Jamestown	163.6	36.0	16.0	1,150		
Monongahela	223 0	38.0	16.6	2,100		
Portsmouth	153.0	38.3	16.6	1,125		
Saratoga	147.6	36.1	16.0	1,025		
St. Mary's	150.0	37.6	15.6	1,025		

STEEL, IRON AND WOODEN STEAM TUGS.

Name.	Length	Beam.	Draft.	Displacement.	Speed.	I.H.P.
	ft. in	ft. in.	ft. in.	Tons.	Knots	
Fortune	137.0	26.0	9.6	450	10.	340
Guana	92.6	20.11⅜	8.0	192.4	11.5	300
Leyden	137.0	26.0	9.6	450	10.	340
Narkeeta	92.6	20.11⅜	8.0	192.4	11.5	300
Nina	137.0	26.0	8.6	357	11.12	388
Rocket	85.8	18.10	7 0	187	8.5	147
Standish	137.0	26.0	9.6	450	10.	340
Traffic	106.0	29.4	9.0	280	10.	....
Triton	96.9	20.9	9.0	212	13.	300
Unadilla	110.0	25.0	10.0	345	12.	500
Wahneta	92.6	20.11⅜	8.0	192.4	11.5	300
Tugboat No. 5	96.9	21.0	8.9	225	12.0	450

WOODEN STEAM VESSELS UNFIT FOR SEA SERVICE.

Name.	Length	Beam.	Draft.	Displacement.	Speed.	I. H. P.
	ft. in.	ft. in.	ft. in.	Tons.	Knots.	
Franklin	367.9	54. 3	24.3	5,170	9.	1,050
Iroquois	198.10	33.10	15.3	1,575	10.7	1,202
Minnesota	264.8½	51. 4	23.0	4,700	9.25	1,000
Nipsic	185.0	35. 0	14.3	1,375	10.7	839
Omaha	250.6	38. 0	16.6	2,400	11.3	953
Pensacola	230.8	44. 6	18.7	3,000	9.	680
Richmond	225.0	42. 6	17.4½	2,700	9.5	692
Swatara	216 0	37. 0	16.6	1,900	10.1	680
Wabash	262.7	51. 4	23.0	4,650	9.15	950

WOODEN SAIL VESSELS UNFIT FOR SEA SERVICE.

Name.	Length	Beam.	Draft.	Displacement.	Speed.	I. H. P.
	ft. in.	ft. in.	ft. in.	Tons.	No En	gines.
Constitution	175.0	45. 0	20.0	2,200		
Dale	117.7	33.10	14.9	675		
Independence	189.0	51. 6	21.6	3,270		
New Hampshire	196.3	53. 0	25.6	4,150		
St. Louis	126.6	32. 8	15.6	830		
Vermont	196.3	53. 0	25 6	4,150		

If the loss of the gallant crew of the Maine will have the effect of compelling congressional attention to the necessity for a considerable increase of the present fleets, they will not have died in vain. Persons ashore usually fall into the habit of considering the strength of the navy from a peace point of view. The Maine disaster would surely find its counterpart in time of war.

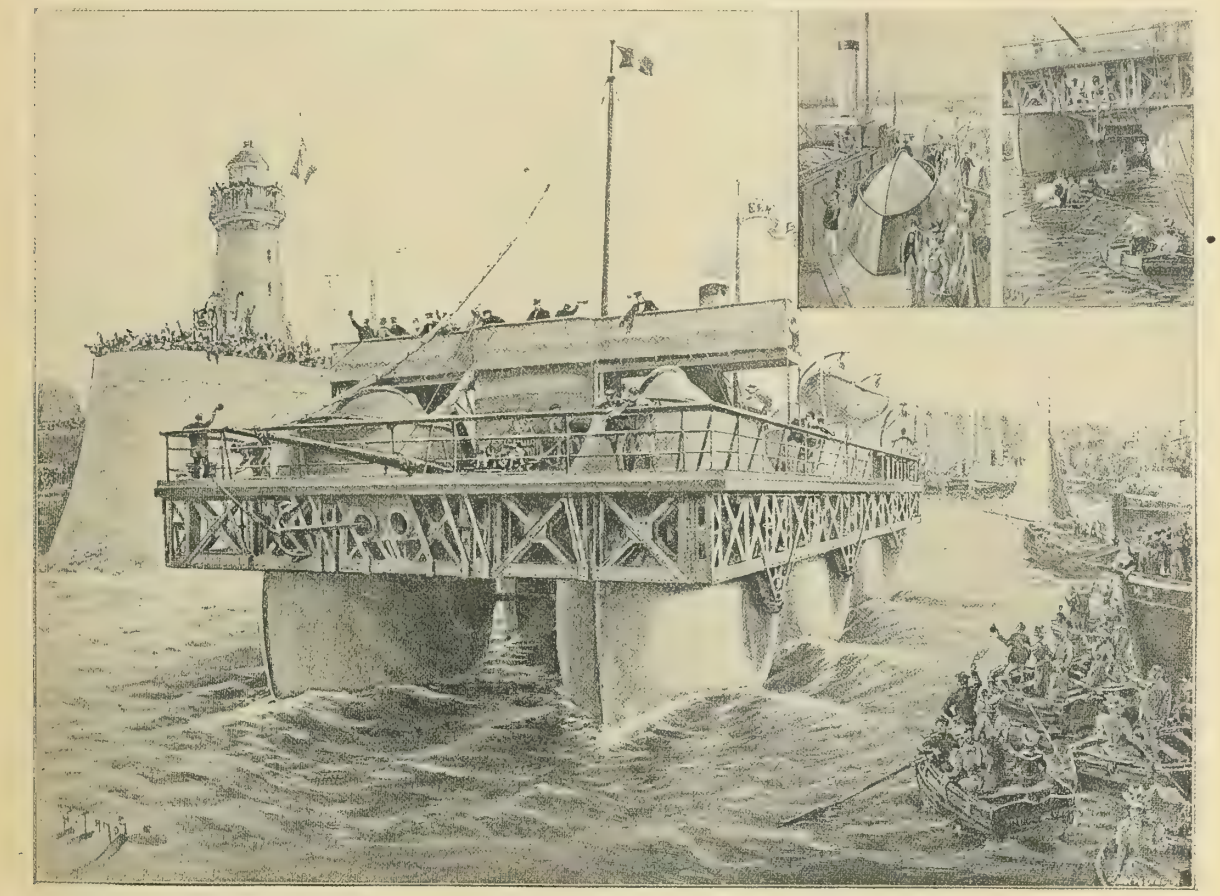
Death of M. Bazin, of "Roller Boat" Fame.

Just as we were going to press last month the death of M. Bazin, the inventor of the now famous "roller boat" was announced. Aside from the personal loss to his family and friends it is much to be regretted that M. Bazin died before he was enabled to carry out his ideas in a large seagoing vessel. The "Ernest Bazin," built after his plans, was considered by experts who had witnessed its performance, as being too small a boat for a proper practical demonstration of his theory.

The "Ernest Bazin" consisted of a rectangular structure mounted on six wheels or rollers arranged vertically along the sides. Each of these rollers had a displacement of about 45 tons and they were connected in pairs athwartships by shafts. By suitable machinery these rollers were caused to revolve slowly, and at the same time a screw of the usual type, immersed in the water, gave an additional propulsive effort. The engines were of 350 I. H. P., arranged to work both the screw and rollers. The special effort of the inventor was to reduce the friction encountered by a vessel passing through the water by causing the immersed portions to have a rolling rather than a rubbing motion. In the trials of the vessel it was found that owing to the number and closeness of the rollers the wave systems created by each came into rapid contact and created such a disturbance of surface conditions that speed was greatly retarded. It was believed by the inventor that with a larger superstructure and fewer wheels this difficulty could be got rid of. As a sea boat the "Ernest Bazin" was said to be rather a success, but as a steam vessel for the transportation of passengers or freight she showed no points of superiority over present designs. It was her experimental value, however, that attracted much serious attention, and among those who studied her operation was Sir Edward Reed, the well-known British naval constructor. In reporting on the result of trials he attended, this distinguished scientist writes:

We began the trials off Havre with very small power and speed. In the first two measured runs only about 112 I.H.P. was exerted by the screw propeller engines, giving, with the rollers at rest, a speed of 4.25 knots. Keeping only the same propelling power at work, but causing the rollers to revolve seven turns a minute by the application of 25.68 I.H.P., we obtained a very remarkable increase of speed, which rose to over 6 knots (more exactly 6.09 knots). I have calculated what the increase of speed would have been had this 25.68 I.H.P. been added to the screw engines instead of being applied to the rollers, and I find that by this means we should merely have added .55 of a knot, thus raising the speed from 4.25 to 4.8 knots only.

In the next experiment the power exerted upon the screw was increased to 295 I.H.P. and the roller power



VIEWS OF THE "ROLLER" STEAMSHIP ERNEST BAZIN, THE INVENTION OF THE LATE M. BAZIN.

to 34.2 I.H.P., the rollers revolving nine turns per minute. I calculate that with the rollers at rest, the increase of horse power upon the screw should have raised the speed from 4.25 to 5.8 knots. The actual speed attained was 6.81 knots, giving an excess of speed due to the revolution of the rollers of 1 knot. It will be seen that this gain is not quite so much as in the previous case, although the power applied to the rollers was somewhat increased—a fact that may be conjecturally accounted for in several ways; but there remains the remarkable fact that the vessel steaming at, say, 5.8 knots, only with 295 I.H.P. applied to her screw, is increased in speed by fully a knot by the application of only 1-9th of that power to her rollers! A further, but small, increase of speed (from 6.81 to 6.97 knots) was obtained by increasing the power on the rollers to 52.2 I.H.P. Small as this increase was, it nevertheless points to the fact that the additional 18 I.H.P. was much more efficient when applied to the rollers than it would have been if applied to the screw propeller.

The views we present herewith are photographic reproductions of views taken for the London Graphic.

An Entire Fleet for "Klondike" Trade.

The most important marine undertaking in connection with the development of the "Klondike" region was begun last month by the organization of the Empire Transportation Co., to operate a line of steamers from Pacific coast ports to Alaska. This is really an extension of the operations of the International Navigation Co. to the Pacific coast. This great American steamship company, as is well known, conducts the Red Star and American Lines in transatlantic freight and passenger trade. The officers of the new Empire Transportation all hold official positions with the International Navigation Co., and they are: President, Clement A. Griscom; Vice-President, W. H. Barnes; Secretary, James J. Hope; Treasurer, James S. Swartz; General Manager, George H. Higbee, and General Agent, Gates D. Fahnestock. The new company commences operations with a fleet of well-known steamers, the Ohio, Indiana, Illinois, Pennsylvania, and Conemaugh. The first four were built by the Cramps several years ago for the old American Line, and when put in service were the finest boats in the transatlantic trade. They are thoroughly staunch vessels, with remarkably good lines, though they do not attain the same speed now as when built. This is because the original powerful and wasteful compound engines were replaced by modern triple expansion engines of less power. After their transfer to the Empire Company the ships were sent to Cramps' yard for a thorough overhauling and refitting to adapt them for the north Pacific trade. When finished they will have accommodation for about 200 first-class and 600 second-class passengers. All the furnishings and equipment will be strictly up to date, including large dining saloons, very comfortable cabins, and electric lighting throughout. The details of heating and ventilation have also received special attention, and a refrigerating plant has been installed on each ship. The fleet will leave Philadelphia some time this month and the first sailing from the Pacific coast will be about June 1.

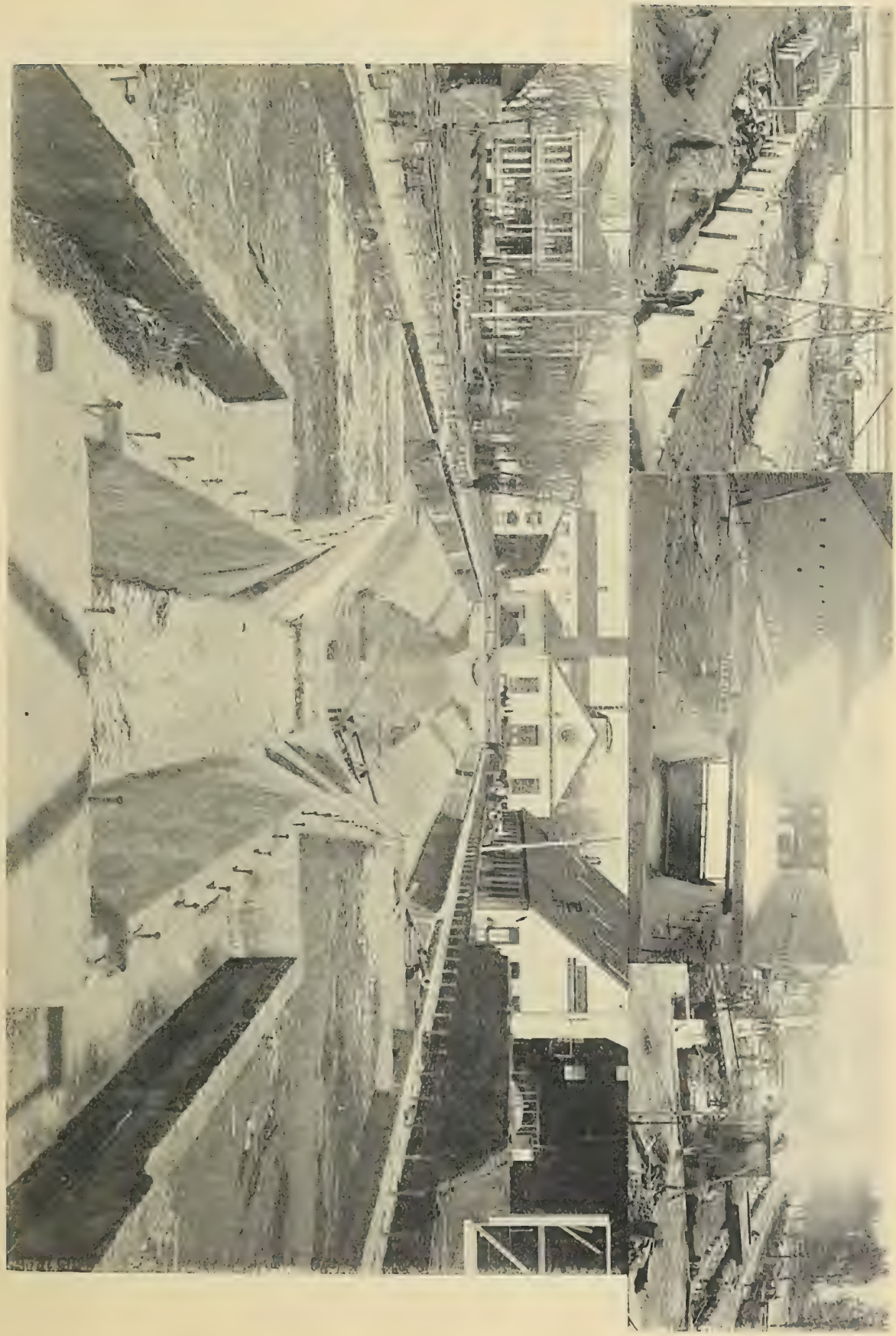
The port of departure on the Pacific coast has not been settled upon, but it is probable that Seattle will be selected, and the northern port St. Michaels. Here the passengers and freight will be transferred to river steamers, which will be operated on the Yukon River, giving direct communication to Dawson City.

Experimental Tank at Washington Navy Yard.

Work on the experimental model tank for the Navy is going forward rapidly at the Navy Yard in Washington. The accompanying photographs, which we are enabled to reproduce through the courtesy of Commodore Hichborn, Chief of the Bureau of Construction and Repairs, show the progress of the work from the original excavations down to the middle of February.

The main building is 500 ft. long, 52 ft. wide, with two extensions, one for office purposes and the other for a pump house. The basin proper is 370 ft. long, 43 ft. wide at the water level, and 14 ft. 9 in. deep from the level of the top of the foundation wall. An inner extension of the foundations will carry the heavy tracks on which the model testing carriage will be run, and the position of these is indicated in the engravings by the rows of holding down bolts. In laying the tracks an absolute nicety of construction will have, of course, to be observed. The carriage has been designed to run at a maximum speed of 33 ft. per second, and this necessitates elaborate provisions for braking and stopping the carriage, without jar, at the end of the course. It will be noticed at each end of the basin there are extensions; that at the south end is 70 ft. long and will be used for balancing and starting the models. The extension at the opposite end is 34 ft. long, and here the apparatus will be installed for stopping the carriage after the completion of each experiment. A uniform length of 20 ft. has been decided upon for the models, the proportion of the model to the represented ship being less or greater as the ship is larger or smaller. Thus a model of a ship 400 ft. long will be one-twentieth of the full size, while that of a 100 ft. torpedo boat will be one-fifth of the full size.

At the present time the brick wall of the building is finished and is ready for the roof trusses. Designs have been completed for the special machinery to be used in towing and recording the performance of the models, and contracts will be let for the construction of this apparatus by the time this appears in print. It has been the aim of the Bureau of Construction and Repair to provide an experimental station which shall in every respect be an improvement over any station abroad. This has necessitated a good deal of original research, but the vast possibilities of the tank will be ample compensation for this labor. At a future time we hope to present some further data concerning this most important undertaking.



VIEWS OF THE U. S. EXPERIMENTAL TANK AT THE WASHINGTON NAVY YARD IN VARIOUS STAGES OF CONSTRUCTION.

HIGH PRESSURES AT SEA WITH SOME CONSIDERATION OF TYPES OF BOILERS.*—I.

BY W. R. CUMMINS.

In commencing, the author referred to a paper read by him in 1890, in which he advocated the use of pressures as high as 250 lb. to the square inch for regular practice, and an increased piston speed over that obtained in the three cylinder, three crank engine as used in the mercantile marine. He suggested then that a four crank, four cylinder engine be designed in which the steam would be used expansively in each cylinder. At the same time he called attention to the unsuitability of the cylindrical return-tube boiler for high pressures, and also suggested a modification in design. Since the date referred to, the use of four cranks had grown in favor, the author stated, but the boiler of 150 lb. to 180 lb. pressure had remained the same as six years before. Meanwhile, however, the water tube boiler had been introduced in various forms, and in many cases had been accompanied by an increase of working pressure. The author said he believed there was only one case of cylindrical return tube boilers working at a pressure higher than 250 lb.; that of the S. S. Inchmona. On this vessel the working pressure is 225 lb. per sq. in. In the present paper the author declared he would first recapitulate the arguments of the former paper as to the economy to be expected from an increase of pressure, and would touch upon the commercial phases of the question; then he would consider the type of boiler best suited to the new conditions; and lastly, would make some suggestions as to the proper design of engine. Having thus outlined his plan of discussion, he continued:

The coal economy effected by substituting the triple-expansion engine with boilers working at 150 lb. pressure for the compound engine with boilers working at 80 lb. is, generally speaking, about 25 per cent. Let it be assumed that in the case of the compound the mean pressure referred to the low-pressure cylinder would be 21 1-2 lb. The total number of expansions requisite to obtain this mean pressure would be 6 3-4. For the sake of simplicity the term "expansions" in this paper will mean the valve expansions—that is to say, the ratio of expansion—neglecting the effect of clearance space, etc., on that ratio. Then, if an economy of 25 per cent is obtained by using a boiler pressure of 150 lb., the mean pressure referred to the low-pressure cylinder of the triple expansion engine will be 21 1-2 plus 25 per cent—say 26 1-2 lb. The total expansions necessary to obtain this mean pressure will be 11 3-4. Thus we have in the case of the compound 95 lb. absolute pressure in the boiler, 6 3-4 expansions, and 21 1-2 lb. mean pressure referred to the low-pressure cylinder; and in the triple expansion engine 165 lb. absolute pressure in the boiler, 11 3-4 expansions, and 26 1-2 lb. mean pressure referred to the low-pressure cylinder. These, it may be stated, are average voyage figures, with the compound using about 2 1-4 lb. coal per indicated horse power per hour, and the triple about 1 5-8 lb. per indicated horse power per hour.

We have next to determine the theoretical economy of steam of 165 lb. absolute pressure over steam of 95 lb. absolute pressure, under the above conditions.

In the first place, Carnot's formula,

$$\frac{T_1 - T_2}{T_1} = \text{efficiency},$$

will not apply to this case, as it does not take into account all the facts regarding the working of steam.

Thus, for steam of 95 lb. absolute pressure,

T_1 (= absolute temperature at which heat is received) = 785 deg. Fah.

T_2 (= absolute temperature at which heat is rejected) = say 80 deg. Fah. + 461.2 deg. Fah. = 541 deg. Fah.

For steam of 95 lb. pressure,

$$\frac{785 - 541}{785} = .310 \text{ efficiency}$$

For steam of 165 lb. pressure,

$T_1 = 827$ deg. Fah.;

$$\frac{827 - 541}{827} = .345 \text{ efficiency};$$

$$\frac{.345 - .31}{.310} \times 100 = 11 \text{ per cent}$$

economy of steam; of 165 lb. absolute pressure over steam of 95 lb. absolute pressure, according to Carnot's formula.

As will be shown further on, the actual theoretical economy is considerably more than this figure. It is probably owing to the misapplication of this formula that the triple-expansion engine has had the credit of its economy put down to the fact of it expanding the steam in three stages instead of two, as in the compound; the argument being that the initial condensation is diminished owing to a lessened range of temperature in each cylinder.

It is well known that when dry saturated steam expands adiabatically doing external work, that a portion of the steam is liquefied, and to calculate the amount of this external work we must know how much of the steam is liquefied during expansion. Professor Rankine gives the following formula for the proportion of steam liquefied during expansion:

$$\text{Proportion} = 1 - \frac{T_2}{L_2}\left(J \log_e \frac{T_1}{T_2} + \frac{L_1}{T_1}\right),$$

where T_1 = absolute temperature at beginning of expansion in deg. Fah;
T_2 = absolute temperature at end of expansion in deg. Fah;
L_1 = latent heat in foot-pounds per lb. of steam at beginning of expansion;
L_2 = latent heat in foot-pounds per lb. of steam at end of expansion.

Rankine's formula does not give the liquefaction for any definite number of expansions;

* From a paper read at the North-East Coast Institute of Engineers and Shipbuilders in Sunderland, England.

hence the temperature at end of expansion must be determined by trial and error to suit the given expansions. This has been done in the following calculations:

For steam of 95 lb. absolute pressure, 6 3-4 adiabatic expansions, and terminal pressure 11 lb. absolute,

$T_1 = 785.084$ deg. Fah,
$T_2 = 658.968$ deg. Fah,
$L_1 = 683{,}674$ foot-pounds,
$L_2 = 753{,}288$ foot-pounds,

and the proportion of steam liquefied at end of expansion = 12.21 per cent.

Thus we have at the beginning of expansion 1 lb. of steam at 95 lb. absolute pressure, and at the end of expansion .8779 lb. steam at 11 lb. pressure and .1221 lb. water.

V_1 = volume of 1 lb. steam at 95 lb. absolute pressure = 4.494 cu. ft.
V_2 = volume of .8779 lb. steam at 11 lb. absolute pressure + volume of .1221 lb. water = 30.379 cu. ft.

$$\text{Ratio of expansion} = \frac{V_2}{V_1} = 6.76.$$

Then, assuming that the above proportions of steam and water do not vary during the exhaust period, and that the back pressure = 4 lb. absolute, we have

Heat received = total heat of 1 lb. steam at 95 lb. absolute pressure = 1212.729 thermal units. Heat rejected = total heat of .8779 lb. steam at 4 lb. absolute pressure = 1018.912 + heat of .1221 lb. water at the corresponding temperature = 18.729 thermal units. Heat utilized = heat received — heat rejected = 1212.724 — (1018.912 + 18.729) = 175.082 thermal units.

For steam of 165 lb. absolute pressure, 11 3-4 expansions, and terminal pressure 10 lb.,

$T_1 = 826.944$ deg. Fah.,
$T_2 = 654.440$ deg. Fah.,
$L_1 = 660{,}110$ foot-pounds,
$L_2 = 755{,}755$ foot pounds,

and the proportion of steam liquefied at end of expansion = 15.24 per cent.

Starting with the same quantity of heat as in the previous case, we have

$$1 \times \frac{1212.724}{1225.493} = .9895 \text{ lb.}$$

steam at beginning of expansion at 165 lb. pressure, and at the end of expansion .8387 lb. steam at 10 lb. pressure and .1508 lb. water.

V_1 = volume of .9895 lb. steam at 165 lb. pressure = 2.737 cu. ft.
V_2 = volume of .8387 lb. steam at 10 lb. pressure + volume of .1508 lb. water = 31.769 cu. ft.

$$\text{Ratio of Expansion} = \frac{V_1}{V_2} = 11.68$$

Let the back pressure be 4 lb. absolute, as before, and we have

Heat received = total heat of .9895 lb. steam at 165 lb. pressure = 1212.724 thermal units. Heat rejected = total heat of .8387 lb. steam at 4 lb. pressure = 973 416 thermal units + heat of .1508 lb. water at corresponding temperature = 23.132 thermal units. Heat utilized = 1212.724 — (973.416 + 23.132) = 216.176 thermal units.

Then,

$$\frac{216.176 - 175.082}{175.082} \times 100 = 23.47 \text{ per cent}$$

economy of steam of 150 lb. boiler pressure over steam of 80 lb. boiler pressure.

To show that this economy is not due to mere expansions, take the case of steam of 95 lb. absolute pressure expanded the same number of times as the steam of 165 lb. absolute pressure, viz., 11 3-4 times; the terminal pressure in this case will be 6 lb., and

$T_1 = 785.084$ deg. Fah.,
$T_2 = 631.323$ deg. Fah.,
$L_1 = 683{,}674$ foot-pounds,
$L_2 = 768{,}332$ foot-pounds.

The proportion of steam liquefied at end of expansion = 13.71 per cent. Thus we have at beginning of expansion 1 lb. of steam at 95 lb. absolute, and at end of expansion .8629 lb. steam at 6 lb. absolute, and .1371 lb. water.

V_1 = volume of 1 lb. steam at 95 lb. absolute = 4.494 cu. ft.
V_2 = volume of .8629 lb. steam at 6 lb. absolute + volume of .1371 lb. water = 52.939 cu. ft.

$$\text{Ratio of expansion} = \frac{V_2}{V_1} = 11.77.$$

Heat received = total heat of 1 lb. steam at 95 lb. absolute = 1212.724 thermal units. Heat rejected = total heat of .8629 lb. steam at 4 lb. absolute = 1001.503 thermal units + heat of .1371 lb. water at corresponding temperature = 21.030 thermal units. Heat utilized = 1212.724 — (1001.503 + 21.030) — 190.200 thermal units.

$$\frac{216.176 - 190.200}{190.200} \times 100 = 13.65 \text{ per cent}$$

economy of steam of 150 lb. boiler pressure expanded 11 3-4 times over steam of 80 lb. boiler pressure expanded 11 3-4 times.

It is thus seen that the mere fact of raising the boiler pressure from 80 lb. to 150 lb., and expanding the same number of times, causes an economy of about 13 1-2 per cent.

The lessons to be learnt from this fact are: first, that "thermal units should be used while they are hot"—that is to say, every opportunity should be taken, when designing cylinders, steam ports, and passages, to prevent steam of higher pressure giving up its heat to steam of lower pressure; and, secondly, that unless we can obtain direct proof to the contrary, there is no appreciable coal economy in expanding steam in several stages.

For steam of 220 lb. absolute pressure, 15 3-4 expansions, 30 lb. mean pressure, referred to the low-pressure cylinder, and theoretical terminal pressure 9 lb.,

$T_1 = 851.04$ deg. Fah.,
$T_2 = 649.516$ deg. Fah.,
$L_1 = 646{,}422$ foot-pounds,
$L_2 = 758{,}439$ foot-pounds,

and the proportion of steam liquefied at end of expansion = 17.10 per cent.

Thus we have at the beginning of expansion .9836 lb. steam at 220 lb. absolute pressure, and at the end of expansion .8154 lb. steam at 9 lb. absolute pressure, and .1682 lb. water.

V_1 = volume of .9836 lb. steam at 220 lb. = 2.41 cu. ft.
V_2 = .8154 lb. steam at 9 lb. absolute pressure + volume of .1682 lb. water = 34.112 cu. ft.

$$\text{Ratio of expansion} = \frac{V_2}{V_1} = 15.80.$$

Heat received = total heat of .0836 lb. steam at 220 lb. absolute pressure = 1212.724 thermal units. Heat rejected = total heat of .8154 lb. steam at 4 lb. pressure = 946.373 thermal units + heat of .1682 lb. water at corresponding temperature = 25.801 thermal units. Heat utilized = 212.724 — (946.373 + 25.801) = 240.550 thermal units.

$$\frac{240.550 - 216.176}{216.176} \times 100 = 11.27 \text{ per cent}$$

economy of steam of 205 lb. boiler pressure over steam of 150 lb. boiler pressure.

For steam of 265 lb. and 26 1-2 + 18 per cent, say = 31 1-2 lb., mean pressure referred to low-pressure cylinder, the number of expansions will be 18 1-2, and the terminal pressure 9 lb. absolute.

T_1 = 867.040 deg. Fah.,
T_2 = 649.516 deg. Fah.,
L_1 = 637,186 foot-pounds,
L_2 = 758,439 foot-pounds,

and the proportion of steam liquefied at end of expansion = 18.16 per cent.

Thus we have at the beginning of expansion,

$$1 \times \frac{\text{total heat of steam at 95 lb.}}{\text{total heat of steam at 265 lb.}} = .9798 \text{ lb.}$$

steam at 265 lb. absolute pressure, and at the end of expansion .8019 lb. steam at 9 lb. absolute pressure and .1779 lb. water.

V_1 = volume of .9798 lb. steam at 265 lb. pressure = 1.833 cu. ft.
V_2 = volume of .8019 lb. steam at 9 lb. absolute pressure + volume of .1779 lb. water = 33 592 cu. ft.

$$\text{Ratio of expansion} = \frac{V_2}{V_1} = 18\ 32.$$

Heat received = total heat of .9798 lb steam at 265 lb. absolute pressure = 1212.724 thermal units. Heat rejected = total heat of .8019 steam at 4 lb. absolute pressure = 930.705 thermal units + heat of .1779 lb. water at corresponding temperature = 27.289 thermal units. Heat utilized = 1212.724 — (930.705 +27.289) = 254.730 thermal units.

$$\frac{254.730 - 216\ 176}{216.170} = 18 \text{ per cent.}$$

economy of steam of 250 lb. boiler pressure over steam of 150 lb. boiler pressure.

The following table shows the relative economy of the different pressures and expansions:

Pressure	80	80	150	205	250
Mean pressure on low pressure cylinder	21½		26½	30	31½
Expansions	6¾	11¾	11¾	15¾	18½
Relative economy	100	108	123	137	145

By this it appears that, by putting up the boiler pressure to 205 lbs., a saving in coal consumption could be expected, and by a further increase of pressure to 250 lbs., a saving of 18 per cent would result. This suggested the question: Would it pay the shipowner to attempt this increase of pressure and consequent saving in coal consumption? In the first place, a substantial gain would have to be assured to compensate for the extra care and attention required for higher pressures. It would thus be necessary, if an increase of pressure was attempted, that it should not be less than 250 lbs., thus gaining the economy of 18 per cent.

For purpose of comparison, continued the author, take a boat 310 ft. by 40 ft. by 21 ft., carrying 3,500 tons deadweight and 4,000 tons measurement on 19 ft. 6 in. draught, fitted with triple expansion engines, 23 in., 35 in., and 60 in. by 42 in., running at 65 revolutions per minute, and indicating about 1,000 indicated horse power, with 26 1-2 lbs. mean pressure referred to the low pressure cylinder. The coal consumption at 16 lbs. per indicated horse power per hour would be 17.14 tons per day, which, with a bunker capacity of 540 tons, gives 31 days' steaming. Supposing that engines and boilers working at 250 lbs. pressure and indicating the same power as the triple were substituted, and that they occupied the same space, and cost the same money as the triple, the shipowner would effect savings: First, in the cost of bunker coals; second, in the smaller bunker capacity required, and consequently more space available for cargo, or with the same bunker capacity the ability to steam longer without coaling. With engines working at 250 lbs. boiler pressure and an estimated economy of 18 per cent, the consumption would be reduced to 14 tons per day. The number of steaming days will average about 190 in the year, and a saving on the bunkers at, say $2 per ton, would be:

$$2 \times 190 \times 3 = \$1,140 \text{ per annum.}$$

The bunker capacity can be reduced 18 per cent and turned into cargo space. The space thus saved would be 4,170 cu. ft. = say, 104 tons of cargo at, say, $12 per ton per annum = $1,250. This added to $1,140 saved on bunkers = $2,390 total saved per annum. The total expenses of such a steamer, less bunkers, would be about $36,500 per annum.

Hence, total expenses with triple expansion engines = $43,01
Total expenses, with engines and boilers working at 250 lbs. pressure..... = 40,320
Saving to shipowners:

$$\frac{43,010 - 40,320}{43,010} \times 100 = 6.25 \text{ per cent of total expenses.}$$

This estimate is based on the assumption that the machinery working at a higher pressure costs the same and occupies the same space as the triple expansion machinery, also that the cost of repairs, engine room stores, and wages are the same in both cases. Suppose, however, that the higher pressure machinery cost $7,500 more than the triple expansion machinery still occupying the same space, then the above saving will be reduced by the interest on $7,500 at say, 8 per cent = $600, and the saving to the shipowner will be only $43,010—$40,920 = $2,090 = 5 per cent of total expenses. Or, suppose that the higher pressure machinery occupies a frame space more than the triple engines, but costs the same money, then the above saving will be reduced by the value of one frame space = 1,776 cu. ft. = 45 tons cargo at say, $12 per ton per annum = $540, and the saving to the shipowner will be only $43,010—$40,860 = $2,150 = 5 per cent on total expenses. If the machinery were to cost $7,500 more, and occupy one frame space more, the saving would be only $43,010—$41,460 = $1,550 = 3.5 per cent of total expenses. From this it will be seen that if the higher pressure is to be adopted it is very essential that the new machinery should not cost any more, nor occupy any more space, than the triple expansion machinery.

We can now pass on to consider the boiler question. The first question which arises is, How will the new conditions affect the transmission of the heat through the heating surface?

From Peclet's experiments and deductions it would appear that the quantity of heat transmitted through a plate varied as (1) the surface exposed, (2) as the difference of temperature of the plate on the fire side and on the water side, and (3) inversely as the thickness of the plate; or

$$M = (t_1 - t_2)\ \frac{C}{E}$$

where M = thermal units transmitted,
t_1 = temperature of plate on fire side,
t_2 = temperature of plate on water side,
C = constant depending on material and state of surface,
E = thickness of plate.

Peclet's experiments, however, were carried out by steam heat only, and are thus not applicable to the case of fire heat.

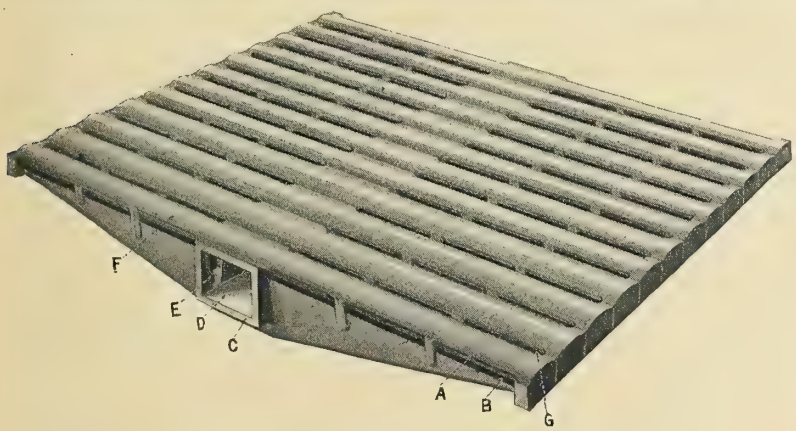
IMPROVED APPARATUS.

Gadey Hollow Cast Iron Grate Bar.

An improved form of hollow cast iron grate bar is shown in the illustrations of the Gadey air grate. This is composed of bars 2 3-4 in. wide, so constructed that when they are placed together to form a grate a uniform supply of air can be blown

SECTION OF GADEY GRATE BARS.

into them and delivered from the interior of the bars, through slots, to the surface of the grate. The air flowing out at the surface of the grate has the effect of syphoning the natural draft between the bars, as well as of itself supplying an increased and well distributed supply of oxygen. In the lettered engraving of the grate A indicates the overhanging edge which prevents ashes from dropping into the slot. B shows the narrow slots

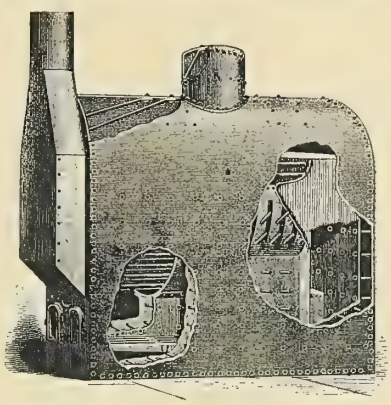


GADEY HOLLOW CAST IRON GRATE.

which act as air-outlets. The faced surface, which forms a joint between the bars, is shown by C and D, and is the supply chamber which is connected with the blower, and carries the air supply transversely across the grate when set in the boiler. The air chamber in each separate bar is indicated by E. The letter F shows the curved top of the bar and G the opening between the bars for natural draft. In the cross section air chamber E is shown more plainly. The blast pipe is connected to a faced joint below the supply chamber D at one side of the grate. In the sectional view the rib on the under side of the top of the bars will be noticed. This not only strengthens the bar but aids in distributing the outflow of air evenly on both sides of the bar. The grate is manufactured by Brown Bros. Mfg. Co., of Chicago, and is marketed by E. P. Gould, 57 East Kinzie St., Chicago, the agent for the United States.

DePuy Double-Firebox Leg Boiler.

A new type of leg boiler is shown in the illustration of the Paragon boiler, just patented by Captain M. DePuy. It is a double-firebox re-



DEPUY LEG BOILER.

turn tubular boiler with center and side legs extending from the water end in front to the water end in the back, thus forming a continuous water leg all around the boiler. Socket bolts stay the fireboxes and shell. These side and center legs, in addition to being open at both ends, are provided with slot openings through the shell, spaced 5 in. apart, which provide for a free circulation of water throughout the entire boiler. The spaces between the center and side water legs are used as fire boxes, there being at the rear a flue box across the flue sheet from which extend horizontal flue tubes terminating at the front header. More space is provided between the tubes directly over the central water leg, thus promoting the free circulation of water over and through this leg; the ends of the side and center water legs being open, the several legs practically form one continuous water leg. The address of Captain M. DePuy, inventor, patentee, is 19 South St., New York.

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DURING the preparation of this issue for the press it became our sad task to chronicle the loss of the second-class battleship Maine, in Havana Harbor, with two officers and a majority of her crew. The horror of the mishap, which without warning or preparation slaughtered more than 250 gallant seamen, was deepened by the sinister rumors which soon spread abroad as to its probable origin. That there was an explosion the results only too horribly proved, but whether by accident or intent was not apparent. Interest in the subject from the point of view of the trained technical mind became intense, and but little satisfaction was to be obtained from a perusal of the inaccurate, if not misleading and absurd reports, bearing on this aspect, in the press of the country. It has thus become for us a duty to present such technical information as would make possible an accurate knowledge of the construction and equipment of the vessel. This is accompanied by authentic engravings illustrative of the warship and her machinery equipment and also by accurate sections drawn to scale. This scale has been made so that only an ordinary two-foot rule is necessary to obtain a clear conception, in dimensions, of the interior arrangement of the "Maine." The amount of space which we have thus devoted to placing facts concerning the disaster before our readers, has compelled the holding over of much other important, technical matter until a future issue.

AS an exhibition of self-restraint and fair play, the attitude of the Executive and Legislative branches of the Government, since the terrible disaster at Havana, has compelled admiration the world over. This calmness is indeed more terrible, and full of portent, than the blusterings and boastings, which many public prints would have the superficial student of affairs believe was the voice of the nation. But it is not of things political that we desire to speak. The appointment of a Board of Inquiry to examine into the causes of the disaster, and the despatch of well equipped wrecking outfit to the scene, showed a desire to promptly discover what agency was responsible for the loss of life and public property. But unfortunately the voice of the courtier was heard amid the silence of wisdom, and a Board of Inquiry was appointed consisting of Captain W. T. Sampson, Captain F. E. Chadwick, Lieutenant-Commander W. P. Potter and Lieutenant-Commander Adolph Marix—line officers to a man. There is no doubt of the character and standing of these gentlemen, whose honorable records and present commands show that they are morally the equals of any. But this inquiry is not to decide whether an ensign properly paid court to the daughter of a civilian; it is an inquiry into the causes of a disaster of a purely mechanical nature. It calls for that most accurate technical knowledge which only special training and long experience can supply. Looking at the composition of the board two members are manifestly well equipped for their duties. Captain Sampson in his connection with the Bureau of Ordnance had rare opportunities for a familiar knowledge of explosives, and Captain Chadwick in the Bureau of Equipment doubtless became expert in his knowledge of coals, and their properties, and of many other more or less dangerous stores. So far the selections were wisely made. But why this discrimination against the great Naval Departments of Construction and Engineering? Structural questions are of vital importance in this investigation, yet not a man on the board would be intrusted by any sane shipbuilder with the construction of even a river tug. Are there no honorable, splendidly trained men among the Chief Constructors of our Navy? men who had drawn or supervised the plans of the Maine. Again, why is not the engineering branch represented? From the Spaniards themselves comes the assertion that a boiler exploded, and yet not an officer on the

board could lay claim to expert knowledge of the construction or operation of the marine boiler. Are there no names on the list of Chief Engineers that stand for sterling merit and knowledge, and as true American courage as that of any man who ever walked the quarter deck? In an examination of the kind undertaken by the Board of Inquiry exact conclusions are not reached by the evidence of any one man. It is the little facts, out of many mouths, that, articulated like the bones of some fossil animal, disclose the living truth. Each scientist on such a board is alive to every utterance which may find response in his special knowledge. The minute fact that the mere disciplinarian would unknowingly pass over, is, to the specially trained, the possible key to the whole situation. The reasons for the selection of the Board of Inquiry may be according to the book of naval etiquette, but are not to be found in the primer of common sense.

THE conservatism of the technical press has been in sharp contrast to the garrulity and inaccuracy of the daily press, with few exceptions. We regret to note, however, the countenance lent by the esteemed Scientific American to wilful misstatement and pictorial misrepresentation as displayed in its issue of February 26. In this issue of our contemporary a "longitudinal section through battleship Maine" is given, which originally appeared in one of the New York daily papers, which paper has persistently sought (at this time) on no basis of fact to prove the criminal responsibility of Spain. In this "section" a "torpedo room" is shown on the platform deck forward of the fore magazine, and underneath a compartment containing what are presumably explosive heads for torpedoes. In reality these compartments were filled with provisions and stores, and the only torpedo heads aboard were stowed in a magazine in the hold abaft the engines. Again instead of the score or so of torpedo heads shown in this "section" there were actually eight heads on board. Each of these was filled with guncotton, to be sure, but this was kept wet—perfectly safe to handle. In fact a seaman with an axe could have chopped the contents of any of these heads in pieces without danger to himself or surroundings. For the information of our contemporary we might add that the Whitehead torpedo, minus the head, is no more harmful than the captain's gig, and not half so cumbrous. Torpedoes are simply small vessels for carrying explosives, modeled on the lines of a fish, so as to offer the least possible resistance when traveling at high speed through the water. They are carried usually in racks close to the torpedo tubes, which in the case of the Maine had broadside discharge on the berth deck. In peace times the torpedo is fitted with a practice head weighted with water to correspond to the weight of the guncotton in the war head. The wet guncotton in this head cannot be discharged except by the use of a small portion of dry cotton and a detonating fuse. Spain has surely enough innocent blood on her hands, without the striving of rival publications to add that of the victims of the Maine disaster, unless proper proof is presented.

THE loss of the Holland-American liner Veendam at sea and the rescue of her passengers and crew by the American liner St. Louis, was the ground work of a tale of heroism as stirring as any the pages of fiction hold. The quiet bravery of the officers of the sinking vessel, in adopting all possible means of saving their ship, and then their passengers, is a fine setting for the splendid seamanship and courage of the rescuing crew. The Old World and the New can both be proud of the humanity of their sons and shake hands across the sea. There is one feature of the mishap, which reiterates an important lesson; the necessity for placing the electric generating plant high enough up in the vessel to prevent the extinction of the lights in case of serious structural damage. In the Veendam this appears to have been the case, for the electric lights were glowing up to the time the vessel was abandoned. When the stoke holds were flooded the donkey boiler furnished the necessary steam to keep the engines and generators running. What would have occurred had the lights throughout the ship been extinguished by the flooding of the engine room is not pleasant thinking. In many vessels, including some of the newest and best equipped, the electric plant is away below, in a corner of the engine room, or in the recess between the thrust blocks, and any rupture of the skin in this vicinity would speedily leave the ship in darkness. The value of having the dynamos well above water was lately illustrated in the wreck of the British transport, Warren Hastings, the engineers keeping the generators going until everyone else had got away.

Discussion on the Parsons' Steam Turbine as Applied to Marine Propulsion.

At a recent meeting of the Institute of Marine Engineers, in London, there was a discussion upon the paper, "The Progress of the Steam Turbine" by Hon. Charles Parsons, which was published in our issue of December last. The Chairman, MacFarlane Gray in opening briefly referred to the principal features of the turbine engine described in the paper, and stated that Mr. Parsons was unable to be present at the meeting, but would be represented by Mr. Martin, who would be prepared to answer any question on the subject. The discussion as reported by the Engineers' Gazette, London, is of much interest.

Mr. Froom inquired the object of Mr. Parsons in having two or three propellers on the one shaft.

Mr. Martin, in reply, said that the original difficulty in using only one screw arose from the cavitation of the water, although probably that was not the only reason why three propellers were subsequently used. A considerable advantage resulted from dividing up the turbine and using two or three shafts with three screws on each. The division also led to a considerable advantage in steam consumption.

The Chairman said he might supplement the answer just given. The gentleman who put the question doubtless supposed that the second propeller on the shaft would simply be working in the water that had been previously set in motion by the first propeller; but the explanation was that the propellers were very small, and this smallness of dimensions exaggerated the distance between the screws. Each propeller acted upon comparatively new water, and in that way the motion created by the first propeller had practically no detracting effect upon the water which was operated upon by the second and third propellers.

Mr. Froom raised a further question as to the action of the steam turbine being due to the impact or reaction of the steam.

The Chairman said he had often explained to members of the institute how pressure and impact were the same thing, and how when steam acted upon a piston, what was called pressure was really impact and reaction. He asked them to take the case of a solitary molecule of steam acting upon an ordinary piston. Let them suppose that this molecule of steam was traveling in the cylinder at the rate of 1,000 ft. per second, while the piston was traveling 1 ft. per second in the same direction. It eventually struck the piston, and the velocity of the impact was 999 ft. per second, as the piston was moving and its velocity had to be deducted to get the velocity of impact. Then the steam molecule rebounded from the piston, and what, he asked, was the velocity of the rebound? The velocity of the rebound was always the velocity of the impact, and, therefore, the velocity of the rebound was 999 ft. per second. But this was rebound from a piston moving one ft. per second, or 998 ft. velocity in relation to the stationary cylinder. It had lost velocity to the extent of 2 ft. per second, and it had lost that velocity in the impact and rebound. Every time that a molecule of steam struck the piston it lost velocity equal to twice the velocity of the piston. In Parsons' engine the velocity of the steam was diminished by twice the velocity of the blade that it struck. The steam lost nothing by striking the stationary blades; it was only the moving blades that it did work upon. The loss of velocity was transfer of energy. In every cubic inch of steam there were more than a million molecules, and each one hit millions of time each second. This velocity was the molecular velocity of steam. The velocity through the turbine was molar or steam velocity, which was the source of power in the water turbine but not in the steam turbine, on the whole. Throughout the action of the steam there was a continuous expansion going on creating steam velocity, which was immediately lost again in impact and made up again in the next expansion when passing the stationary deflecting blades. In the tortuous steam canals formed by the deflectors they had steam expansion in its best form, free from initial condensation along with the impact action or reaction of the hydraulic turbine.

Mr. Ruthven said there were two points upon which he should like further information. First, he would like to know the quantity of water that was evaporated by the boilers at any given speed; and, secondly, the force that was on the thrust at the time—the propulsive force.

Mr. Martin said he did not know that he could give the information just asked for off-hand, but would furnish it subsequently if possible.

In reply to further questions the Chairman said that the diameter of each propeller was 18 in. He could not give the pitch. According to the speed of the vessel the pitch must have been between 2 ft. and 2 ft. 6 in.

Asked the object of having three propellers in line.

The Chairman said that if the three times three propellers were not put three in a line they would require nine shafts instead of only three. Mr. Parsons at first thought that a difference in pitch would be better, and he made them so. He was in doubt, and he asked nature by experiment to tell him which he should use. The answer he obtained was that the practical benefit of variation was so small that it could not be measured, but he could very easily measure the advantage of having the nine propellers all the same, and he, therefore, made them all alike.

Mr. Ruthven said it would be interesting to many members to know how the little curved blades in the steam turbine were made.

Mr. Martin replied that at present these blades were wire drawn. They were fitted with a square base and keyed into the shaft and calked. The fitting of the blades into the shaft was not at all a difficult operation. They could be put in very quickly.

Mr. Smith said it would be interesting if they could be informed what would be gain or loss if, instead of allowing the steam to go below the atmosphere, Mr. Parsons made the final above the atmosphere. Could he possibly get the latent heat back again in the boiler, and, if so, what would be the gain or loss by it?

The Chairman said it would take a long time to answer Mr. Smith's question. It had been the dream of a great many would-be inventors to put the latent heat back again. These men imagined that the steam engine was handicapped by the latent heat of water being so great. The Merchant engine and other follies had, therefore, been put before the public. When a better knowledge of steam was obtained it was found that the greatness of the amount of the latent heat of water was the secret of the greatness of the economy of steam power.

Mr. Ruthven asked what value Mr. Parsons got out of the coal by using his engine—whether more or less than in an ordinary engine?

The Chairman: "He claims it to be as economical as the most economical engine, and the results obtained by the careful experimental tests made by Professor Ewing, the great authority on steam, corroborate this claim."

Mr. Swift said he should very much like to get the pitch of the blades on the Turbinia's propellers. By the water-turbine they could get certain positive data from the angles of the blades, pressure, etc., and by working through the turbine they might get to know something by using the expansive properties of steam, but until they got an indicator diagram of this engine how could they tell what horse power was obtained per pound of coal? That was a point which Mr. Parsons was working out, and he thought it might be left with him for the present. But there was another practical point. The weight of this motor in the Turbinia was said to be three tons, but this appeared to

be only half the engine. Mr. Parsons said that he proposed to fit another turbine to take the boat astern at the rate of 10 knots an hour. But what was 10 knots an hour astern with a boat going 34 knots an hour ahead? In his experience they could never get a ship astern fast enough to please the people on the bridge, and to get the same result astern as ahead they would have to double the plant. There could be no mistake that the thing was coming. The turbine would be the thing of the future, but they must not jump to the conclusion that the motor which had been shown them was a complete and pertect engine. He should like to hear the views of other gentlemen present as to whether in a boat going 34 knots an hour ahead a power to go only 10 knots an hour astern was sufficient?

Mr. Martin said he believed that the power to go astern at 10 knots was in accordance with usual requirements. Could any steamer go astern as fast as she went ahead?

Mr. Swift: "But in the present steamers you have the full power of the engines whilst reversing."

Mr. Martin said he thought that for all practical purposes the power to go astern at 10 knots was sufficient. It was very easy to get at the efficiency of the turbine engine when it was connected to an

Mr. MacLarran asked if Mr. Parsons made any provision for holding the weight of the go-ahead screws when the vessel was going astern.

The Chairman, in reply, said it was not necessary to make any provision for holding the screws, because when the vessel was going astern the other screws would simply revolve with the water and cause the turbine to revolve. Mr. Swift had raised a very interesting question, but his (Mr. Gray's) view was that the power to go astern at 10 knots was quite sufficient. It must be remembered that Mr. Parsons could start his engine full speed astern at once.

MISHAPS AT SEA.

Loss of the Holland-American Liner Veendam.

The Holland-American line steamship Veendam, bound west from Rotterdam for New York, with passengers and cargo, was abandoned at sea early on the morning of February 7, in a sinking condition. The passengers and crew were taken off by the American Line steamship St. Louis, bound for New York, which was following the same transatlantic course. No lives were lost, and the St. Louis arrived in New York about her regular time, having lost only four hours in the work of rescue.

Upon the arrival of the St. Louis in port the officers and crew of the Veendam were transferred to the outgoing Holland-American liner which was detained for this purpose, and the official investigation will be held by the Dutch authorities. There was consequently little opportunity for securing any intelligent technical account of the mishap, had any of the officers indeed been disposed to express their views. The facts, as stated by passengers on the lost liner and by the officers of the St. Louis, are briefly:

HOLLAND-AMERICAN LINE STEAMSHIP VEENDAM ENTERING THE PORT OF NEW YORK.

The Veendam sailed with a full cargo and nine cabin and 118 steerage passengers, February 3. When three days out, and then about 600 miles due west of Land's End, England, about 5 o'clock in the evening, a heavy shock was felt by those on board, followed by a stoppage of the engines. There was a rough sea on at the time. The engineers reported the shaft broken and the after compartments rapidly filling. All the available steam pumps were started, and the hand pumps rigged above, and manned by the crew and able-bodied passengers. The water rose steadily, and Captain Stenger made preparations for abandoning the ship. As she lay in the track of

transatlantic steamers, he lit distress signals, which about 1 o'clock the next morning were discerned by a west-bound steamer. This proved to be the liner St. Louis, Captain Randle. In response to the request of Captain Stenger three boats were ordered to the rescue of the sinking ship, and in these and one of the boats of the Veendam the crew and passengers were transferred to the St. Louis, without mishap. Captain Stenger, before leaving, set fire to his ship, which was then so deeply immersed that the lower row of port holes was below water.

When rescued the navigating officers of the Veendam expressed the belief that the ship had collided with a derelict, which had torn a hole in the stern and broken the shaft. This, however, is highly improbable. All the circumstances so far as yet known point to the breaking of the tail shaft in the stern tube, between the bearings, with the result that the outboard end, weighted down by the propeller, came into violent contact with the surrounding metal, and the energy stored up in the propeller was expended in breaking the stern tube and the aft framing, letting in the water. The engines were stopped promptly when the break occurred and were not injured, as, owing to the roughness of the weather, the engineer on watch was standing by. An immediate inrush of water through the tunnel, the door of which was probably open, flooded the engine room, and meanwhile the after compartment was filling through the rents in the skin. When the after compartments filled the head of water probably sprung the doors leading into the compartments forward of the engines, and the fires were drowned out. Meanwhile, however, the donkey boiler was fired up, and steam was thus kept on the dynamo engines.

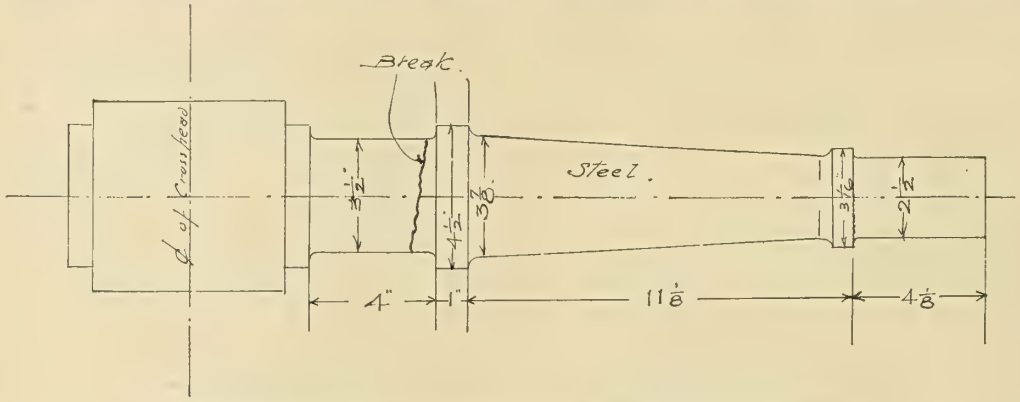
Our illustration shows the Veendam steaming up the North River, in New York harbor. She was an iron single screw vessel, built in 1871 by Harland and Wolff, at Belfast, Ireland, for the White Star Line, under whose flag she was known for many years as the Baltic. She was a strong, good seaboat, and represented the best practice of her time. Her dimensions were: Length, 420 ft.; breadth, 40 ft. 9 in., and depth, 31 ft. Originally she was fitted with compound engines, but when transferred to the Dutch flag she was refitted with new triple expansion engines. At the time of her loss she was valued at $200,000, and the cargo about $300,000.

Accident to C. & O. Transfer Steamer Louise.

On the morning of January 18, while making her usual trip to Newport News from Norfolk, the transfer steamer Louise, of the Chesapeake and Ohio R. R., met with an accident that almost completely destroyed her engine.

While the piston of the single cylinder beam engine was on the up stroke, the port side of the crosshead broke, completely disengaging the port side rod, thus throwing the whole strain and creating a heavy bending moment on the starboard rod. This rod bent, breaking the side gibs, and the rod gave away, allowing the piston to fly up against the top cylinder head. This latter was broken into numberless pieces, one of which came near killing the Engineer.

Before the piston and rod fell, the walking beam, carried by the momentum of the wheel, returned on its downward movement and catching the top end of the piston rod bent it over toward the shaft, thus splitting the cylinder for about six feet of its length. This

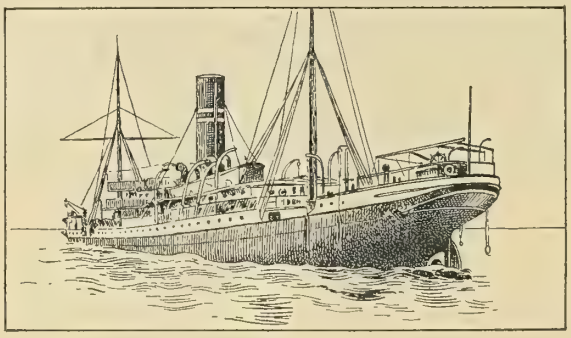


SKETCH SHOWING BREAK IN CROSSHEAD OF TRANSFER STEAMER LOUISE.

also broke the wrought iron strap of the beam, thus causing the breaking of the air pump rods and a number of the holding down bolts of the walking beam bearing caps. The accompanying sketch shows the wrought steel crosshead and the point at which it broke.

It is interesting to note how complete was the chain of circumstances which caused this damage. The break occurred when the piston had traveled about one-third of its stroke, about the point of greatest combined pressure and momentum, and the force of the blow was more than could be expected of any engine to withstand. Had the piston been nearer the end of its stroke the cushion and the reduced forward pressure might have counteracted each other, and thus lessened the extent of the breakdown to a very material degree.

At the time of the accident the engine was making about twenty-two revolutions per minute, under a steam pressure at gauge of 65 pounds.



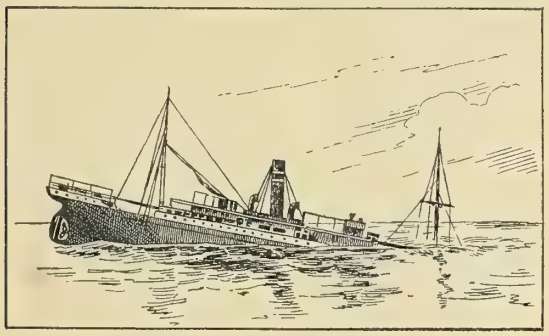
S. S. TAI-HOKU—DOWN BY THE HEAD.

A close estimate would put the damage at about $4,000. She is being repaired at Baltimore, Md.

Loss of the Japanese S.S. Tai-Hoku.

Among oddities in marine photography, a set of views taken by Cecil Lightfoot, of London, of the sinking of the steamship Tai-Hoku off the Portuguese

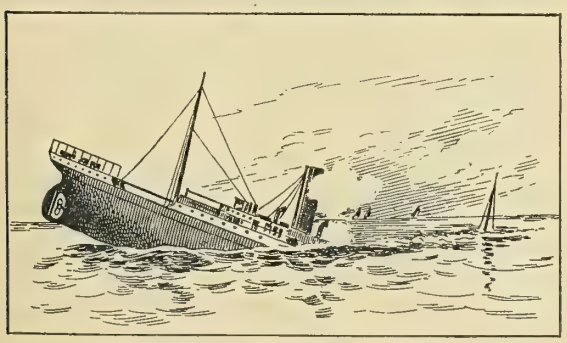
coast, is unique. The views which we here reproduce were originally published in the Strand Magazine, together with an account of the mishap. The steamship had been built at an English East Coast yard for the Osaka Steam Navigation Co., of Japan, and was in every respect an up-to-date passenger liner. She left Antwerp with a miscellaneous cargo, and when five days out, in a thick fog, was run down by the freight steamer Eastbourne. After the collision the Eastbourne dropped out of sight, and the Tai-Hoku was found to have 5 ft. of water in the forehold. So far as any observation of the exterior of the hull went



S. S. TAI-HOKU—GOING DEEPER.

the steamer did not appear to be damaged. Nevertheless the inflow of water continued, and by next morning there was 16 ft. of water in the forehold. Captain Conradi determined to stay with the ship, however, but was unable to communicate with other passing vessels owing to the density of the fog. When the carpenter reported 22 ft. the captain ordered the crew into the boats, and Mr. Lightfoot brought his portable camera away with him.

"After taking to the boats," he said, "we remained very near the ship—within a hundred yards or so. By this time day had dawned, and I was able to take the first two photographs. There was, however, a considerable interval between them. After two or three hours, a large vessel, which proved to be the Millfield, of Whitby, bore down upon us, in response to our flag signal. The captain of this ship conferred with our own commander as to the desirability of towing the Tai-Hoku, and Captain Conradi and some of the officers once more went on board their ship to make the necessary arrangements. Immediately, afterwards, however, the sinking steamer began to

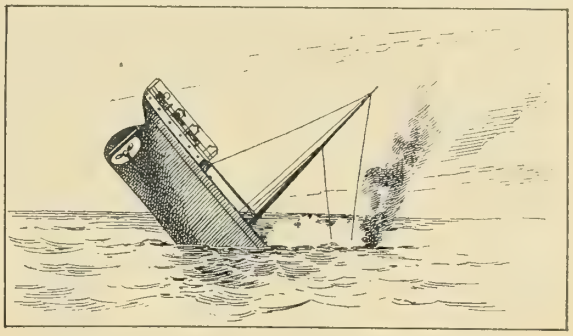


S. S. TAI-HOKU—LAST FEW MOMENTS.

roll heavily, and the attempts at towing had to be abandoned.

"At our request, the Millfield left us immediately after this, she being in a hurry to get home. It was our intention to row up the Tagus to Lisbon, but the crew being of poor quality, this proved a pretty difficult matter. At any rate, we determined to see the last of our ship. The end was now very near. One extraordinary occurrence that hastened it was the displacement of some of the machinery, which, as the Tai-Hoku's head began to go down, and her stern to come up, fell right through the ship with a rumbling sound like distant thunder, and doubtless made another great breach in the bow.

"After another period of anxious waiting, the bridge fell forward, at the same time jerking the cords that communicated with the sirens, and causing them to send a wierd scream over the waters. The next moment, having, so to speak, wished us farewell, the huge ship dived deliberately head-foremost into 300 ft. of water, and was never seen again. As the sea



S. S. TAI-HOKU—THE FINAL PLUNGE.

rushed into the furnaces, steam and water gas were generated; and these, rushing up through the smokestack, caused a kind of explosion, which is very plainly seen in the last photograph I took, just as the ship was disappearing. The upward rush of steam carried a great quantity of soot from the flues, and this caused a dark cloud to hover over the place where the Tai-Hoku sank. There was no whirlpool of any kind. When this great vessel of 3,100 tons took her last dive, the little flotilla of boats could not have been more than 150 yds. distant. Standing by after her disappearance, we saw pathetic bits of wreckage coming slowly to the top—hen coops, a boat, fire buckets, seats, life belts, and so on.

"When we had seen the last of our ship we set to work to row to Lisbon. At about two miles from land a vessel bore down upon us and met us at Cascaes Bay, a little to the north of the River Tagus. She proved to be a Portuguese pilot cutter."

The Tai-Hoku was about 330 ft. long, 43 ft. beam and 28 ft. deep. With her cargo she was insured for $500,000.

Burning of the S.S. Stockholm City.

The tramp steamer Stockholm City, 1,759 net tons, arrived at Newport News recently, badly damaged after a desperate battle with fire at sea. Captain E. J. Richards reported that on January 17, at 5 o'clock in the morning, smoke was observed arising from the starboard coal bunkers amidships. All the pumps were immediately started, and the crew began to dig into the bunkers to try and reach the seat of the fire, but this was useless, for an hour later the flames burst out through the side of the starboard alleyway, showing that the combustion must have been going on for some hours. Immediately the flames mounted to the deck, and although all hands were hard at work, the fire gained complete mastery of the midship part of the vessel.

After burning fiercely for several hours the fire was held under partial control, and although it burned for five or six days after, constant watchfulness and unremitting labor saved the ship. All charts, nautical instruments, books and provisions were destroyed; also the personal effects of the officers. But two boats only were saved, one badly damaged.

The officers, engineers and crew worked like men, but the firemen showed a cowardly spirit. They came

aft, and, after eating the few loaves of bread that were left, hoisted a distress signal, consisting of a bucket and one of their blankets, which was promptly lowered by the Captain. When the vessel reached dock her sides and deck houses were found to have bulged out in places to the extent of 3 in.; all her upper works were destroyed, and it was evident that she had stood all that was possible without sinking. She was completely gutted amidships, bridge and steam steering gear gone, and the engine saved only by almost superhuman exertion. At the time the fire broke out the ship was about 550 miles west by south of Cape Henry, and as all the charts and instruments had been destroyed except the compass in the hand steering compartment aft, and this not having been adjusted, the Captain was rather puzzled as to what to do. Eventually he steered due south until parallel with Cape Henry, and then with the North Star abeam he made a direct course for the Chesapeake, reaching his port in two days and a half.

The damage will amount to about $35,000; temporary repairs are being made by the Newport News Shipbuilding and Dry Dock Co. The engine is a compound 38 in. and 71 in. by 45 in. stroke, and is but slightly damaged, although the walls of its compartment are bulged and strained, and during the return trip the temperature was fearfully high. The fire is supposed to be due to spontaneous combustion.

Other Recent Steamship Losses.

The loss of the steamer Clara Nevada in the Alaska trade, off Seaward City, in Berner's Bay with 25 passengers and crew, was reported. She is supposed to have been destroyed by an explosion.

Captain William Scroggie and the officers of the British steamship Dago were taken from their ship in mid-ocean by the North German Lloyd liner Aller and landed in New York. The Dago was on a voyage from Leith to Baltimore in ballast, and when eight days out the main steam pipe broke. Repairs could not be made, and the pounding of the heavy seas caused the Dago to spring a leak. The water finally drowned out the fires and stopped the pumps, and the vessel was in a sinking condition when the Aller was sighted. A life boat from the Aller took off the crew of the Dago after three trips in a terrific sea.

During a heavy gale the steamer Tillie foundered off Barnegat, causing the loss of several lives of persons on board. It was generally understood that she was engaged in a filibustering expedition, carrying men and munitions to the Cuban insurgents. The Tillie was a wooden steamer, built in 1862, and had been used for many years as a freight carrier by the Vermont Railroad Co. On her last voyage she cleared for Tampa, but was supposed to have taken aboard her cargo of war material from a lighter, off Montauk Point. She developed dangerous leaks when the weather got stormy. When the question of sinking became a matter of time only a cowardly spirit was manifested by those on board. Two boats were lowered and filled dangerously full, and these pulled away, leaving Captain Berry and seven others on the sinking ship. About this time the big five-masted schooner Governor Ames came along and rescued those in the boats, and also sent a boat to the Tillie and took off four of those still on board. According to the reports of the survivors the Tillie went down before the boat from the Ames could make a second trip. All sorts of ridiculous stories regarding damage to the machinery were subsequently published in the daily papers, the loss being attributed to the work of a Spanish spy. In reality the only cause of surprise would have been the safe arrival of the Tillie at Cuba. She was an old boat, staunch enough in the still waters of a harbor, but not fitted to encounter rough weather, which caused the opening of her seams.

CORRESPONDENCE.

Continued Discussion of Walschaert Valve Gear.

Your correspondent is quite right in his conclusion that there is no diagram like Zeuner's circular diagram, that can be applied to radial valve gears. The Walschaert gear is the most regular and symmetrical of any of the common forms of radial gears, and I know from trial that Zeuner's circular diagram does not give even approximate results for it, and that the irregularities of such gears as the Marshall gear and the Joy gear are larger. The only satisfactory way of studying any radial gear, or for that matter any link-motion, is by the aid of a model, but the model for such a purpose need not be very elaborate or expensive. In fact there is a decided advantage in using a model made of wood and laid out on a drawing table as I have shown in my *"Valve Gears for Steam Engines,"* for then, geometric constructions can be made in connection with the model, and in many cases results can be obtained directly instead of by the cut-and-try method.

I have given a figure to show how a complete wooden model can be made for the gear given in connection with my communication in your January number. The crank and eccentric are represented by a flat plate, with a screw for the bearing at the middle of the shaft. The center of the eccentric is at the middle of the small dotted circle which represents a disk of wood or other convenient substance, and which must be large enough to take three screws to fasten on the return crank, which reaches from the eccentric to the crank pin. This inversion of the construction as compared with the gear itself where the eccentric is replaced by a pin in the end of a return crank from the crank pin, is convenient and is of course, proper for a model which gives motions only and does not transmit power.

The cross head is a block moving in guides on which the stroke and its fractions may be laid off, and carries the offset for the link connecting it to the combining lever. The valve-rod head is also a block moving in guides on which the inside and outside laps can be laid off.

The link is represented as cut from a board; it may be convenient to make the bearing surface of the slot of brass plates that can be cut to the right radius independently and adjusted to let the link-block move freely with little backlash. On the back of the link a brass plate may be secured by screws passing through straight slots in the link as shown, so that it may be moved inside or outside of the link arc as may be desired. A screw through this plate into the table or drawing-board will serve as the trunnion.

The several links, rods, and levers are strips of hard wood fastened together with counter-sunk screws.

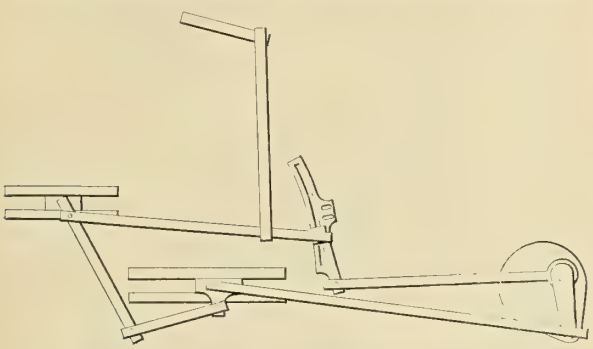
Such a model may appear crude at first sight, but if properly made and used it will give accurate and correct results, and will endure considerable service. It is needless to say that the dimensions must be laid off accurately, but some discretion must be used to maintain them in the process of drilling the holes and putting in the screws. After the location of a screw is determined, take a center-punch ground to a sharp, true point, hold it squarely in place and hit it a square blow with a hammer. Then take the piece of wood to a lathe or a good rapid drill-press and drill the hole with a twist drill. A hole into which a screw is set should be drilled a little smaller than the shank of the screw at the thread, and a hole in which a screw acts as a pin must be a little smaller than the body of the screw, under the head. The head should be V shaped and counter-sunk, as it then forms a cone bearing by which wear can be taken up.

It will be noted that there are four heights or planes of elevation above the drawing-board or table.

The plate for the crank and eccentric, the link, and the two slides representing the crosshead and valve-rod head, are next to the table, as is also the arm of the reverse arm. -The -eccentric rod, combination lever and the link block are at the next stage of elevation. The return crank, the radius rod and the link from the crosshead to the combination lever are at a third height, while the connecting rod and suspension link or hanger are at a fourth height. Distance pieces will be required at places, as for example between the hanger and reverse arm.

The greater part of the dimensions and proportions of this or any other valve gear are imposed upon the diagram by the general construction of the engine. Thus the piston rod and valve rod will have their relation determined by the size and proportions of the cylinder and the valve with its steam chest and passages. The combination lever must be long enough to avoid too large an angular displacement from the vertical; 45 deg. should be taken for the maximum displacement, and less should be used when possible. The displacement of the radius rod from the horizontal should not exceed 15 deg.; less is better.

The gear should be set up "square," that is, the link should be erect when the crank is on a dead point and the combination lever should be vertical when the valve is in midposition, and in general all parts should swing or vibrate equal amounts from a vertical, or horizontal, middle, position. It is true that intentional irregularities introduced with discretion



SKETCH SHOWING COMPLETE WOODEN MODEL.

may improve the action of the valve at certain grades, but other irregularities, are certain to result, which may be very undesirable.

There is, however, one point which has a great influence on the adjustment of the gear and which is quite under the control of the designer. That is the trunnion of the link. Normally the trunnion should be on the arc passing through the middle of the slot of the link, but it may be set either inside or outside of that arc, if the designer finds it advisable. It is for this reason that the brass plate carrying the screw representing the trunnion, is made adjustable. This adjustment of the trunnion is symmetrical in its influences, and produces the same effect in backing as in forward gear, and does not interfere with the lead, which remains constant for all grades. Of course the location of the trunnion screw in the table or drawing-board must be changed to correspond with the displacement inside or outside of the arc, assigned to it. Perhaps it will be as well to set up the model with the trunnion on the link arcs and investigate the action of the valve at all grades. Then move the trunnion a definite fraction of an inch, and make another investigation of the action of the valve.

There is, however, a direct way of finding the location of the trunnion for equalizing the cut-off at a certain fraction of the stroke or for any such a purpose. Suppose the first investigation of the valve-action with the trunnion on the link arc has been made, and that the cut-off appears to be unequal at some grade, say at one-third stroke. To equalize the cut-off at that grade proceed as follows: Place the reverse-arm at the right position to give the mean cut-off at one-third stroke; the head-end cut-off will be too long and the crank-end cut-off too short. Place the cross-head at one-third stroke at one end; secure it as well as the reverse-arm by placing weights on them. Secure the eccentric-rod by placing a block under it near the link, and a weight over the block. Now loosen the screws fastening the brass trunnion plate to the link and tip the link till the valve shuts to give cut-off. Note how far the link slides on the trunnion plate, and move the trunnion screw the same distance in the drawing board or table; this will require the link and some other parts of the model to be taken up. Set up the model with the new location of the trunion and make another investigation of the action of the valve. It is probable that there will be some slight inequality of cut-off at the assumed grade, but if the cut-off is practically equalized at one-third stroke the whole action of the valve is likely to be satisfactory. It must be borne in mind, that a half inch inequality at a third cut-off may be of much importance, while an inch inequality at seven-eighths cut-off is of little consequence.

It is possible to get along with only a partial model, completing the work by construction. For example we may use a piece of cardboard on which the link-arc at the middle of the link-slot is drawn, instead of the link with a sliding block; other lines and points may be drawn and located as required on the same cardboard. We shall need also two strips of wood to represent the combination-lever and the radius rod. They should be joined together at the proper place by a pin or screw. It will be convenient to refer to Fig. 1, page 26, of the January number, in the description of the construction to be made with these adjuncts, noting that that figure represents the gear with the crosshead at about three-fourths return stroke. Draw a diagram like Fig. 1, except that the crosshead is to be placed at the fraction of the stroke for which the cut-off is to be equalized, say at one-third stroke. The connecting rod C D, crank A B and eccentric A H are readily located. The point J may now be located by drawing arcs from H and L with the proper radii, and the cardboard link-template can be placed on the drawing with the points I and J at the corresponding points on the drawing. Now locate G at a distance from its middle position equal to the outside lap, that is at the proper place to give cut-off. Take the strips of wood representing the combination lever and the radius rod, and apply to the drawing, one point at G, one on the link-arc and the other on a circle drawn with D as a center and a radius D E; this gives the location K F G E D, and also of the point M. From M locate the point N of the reverse arm P N.

Now make a similar construction for cut-off on the return stroke, thus finding another location of the point N. Clearly these two points should coincide if the cut-off is to be at one-third stroke for both ends. Take a point half way between the two locations of N for its true location. Let G E remain fixed; place a weight on it for that purpose and let F K move up or down as may be required to correspond with the assumed location of N. K will probably be displaced from the link-arc during this operation. If so fix the point J and tip the link until it comes to the point K and note the direction and amount that the point L representing the trunnion on the link template is shifted from the point I on the drawing board. This is the amount by which the trunnion is to be set off from the link-arc. This construction must be made with much care and accuracy, and is liable to more error than will be found on a properly made model. It is hardly necessary to point out the advantage of the model in that all the properties of the gear for a given setting can be readily investigated.

C. H. Peabody.

EDUCATIONAL.

ELECTRICITY ON BOARD SHIP, PRINCIPLES AND PRACTICE.—VII.

BY WM. BAXTER, JR.

The diagrams illustrating the winding of field coils given in the last article represent what is called series winding, this name being given to it because all the current that passes through the armature passes through the field coils. The arrangement is very simple, but is only used for motors that are not desired to run at a constant speed, and for generators that are not desired to maintain either a constant current or a constant electro-motive force, or pressure. Whenever it is desired that the current remain constant, as is the case in arc lighting circuits, some form of mechanical regulator is attached to the machine, but if it is desired that the electro-motive force remain constant, as in incandescent lighting circuits, the result is attained without the complication of mechanical regulators, by resorting to a different style of field winding. This winding, in a generator, will give a constant pressure and in a motor will maintain the speed uniform, provided the current pressure does not change. There are two types of winding used for accomplishing these results, the simplest of these is known as the shunt winding, the other as the compound winding, when applied to generators, and as the differential winding when applied to motors.

The difference between these two styles of winding and the plain series can be understood from Figs. 38 and 39, the first being the shunt, and the second the compound or differential. In the shunt winding only a small portion of the current that passes through the armature passes through the field coils, if the machine is a generator; if it is a motor, all the current supplied to it does not pass through the armature, a small part going by the way of the field coils. Fig. 38 shows this winding applied to a motor. In this case the current is supplied from an external source, and as will be seen from the diagram it passes down the wire P until it reaches the point D where it branches, part going to the commutator brush, and part to the field coils.

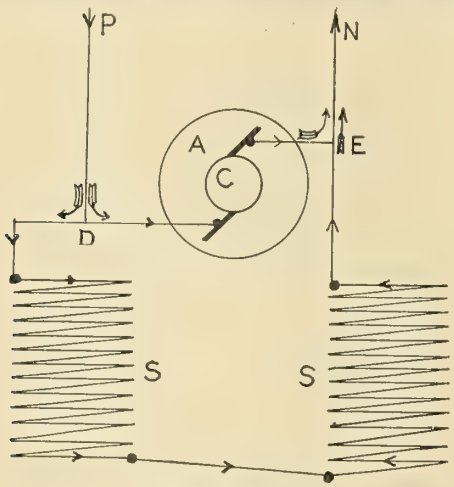


FIG. 38.

The two branch current meet again at E, after one has passed through the armature and the other through the field coils. If this diagram were to represent a generator, the current on reaching the point E would split, and part would pass into wire N and part would go to the field coil. The two currents would come together at D and pass as one to the armature.

The compound winding shown in Fig. 39 is a combination of the series and the shunt. The main practical difference between the shunt and compound windings is, that the latter gives closer regulation. As the principle of operation of the two is substantially the same the explanation of the compound will be clearer after the operation of the shunt is fully comprehended; we will, therefore, proceed to explain in the latter.

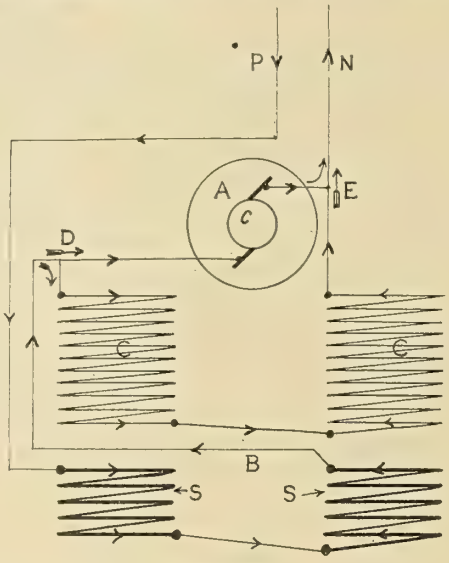


FIG. 39.

As has already been explained, the rotation of an armature in a magnetic field developes in the wire wound upon it an electro-motive force, or electrical pressure, this is true, whether the machine is a generator or a motor, but in the latter this pressure is opposed to that of the current that operates the machine, that is, it is a back pressure, and is therefore called the counter electro-motive force. Whether the electro-motive force is counter, or direct, it will be proportional to the strength of the field, that is to the number of lines of force passing through the armature and the velocity of rotation. If the field remains constant, the electro-motive force will increase with increase of velocity of rotation, and will decrease with decrease of velocity. If the velocity remains constant, the electro-motive force will vary with the strength of the field. If both field and velocity remain constant, the electro-motive force will remain constant. The amount of current that any given electro-motive force will drive through a wire will depend upon the resistance it encounters, being small when the resistance is great and large when the resistance is low. If the resistance is reduced to one-half, the current will be doubled with the same electro-motive force. If the electro-motive force increases and the resistance remains unchanged, the current will increase in direct proportion with the pressure. If pressure and resistance remain unchanged, the current will remain constant.

Remembering the above simple principles, if we regard Fig. 38 as the diagram of a motor, we will see that the current entering through wire P when it reaches the point D will divide between the two paths in amounts proportional to the resistances of the two circuits. The resistance in the field circuit is simply the resistance that the wire opposes to the passage of the current and will remain unchanged, therefore the current passing through the field will be constant as long as the pressure does not vary. The resistance of the armature circuit is made up in part of the resistance of the wire to the passage of the current and in part of the counter electro-motive force, the latter being by far the greatest part of the whole. As the current through the field

coils will remain constant, the magnetism developed thereby will be constant, and as the electro-motive force, or the counter electro-motive force, will not vary at a given velocity as long as the strength of the field remains constant, it follows that a given number of revolutions of the armature will be required to develop an electro-motive force sufficient to balance the direct pressure when the current is of a certain strength. In order to get a given amount of power out of the motor it is necessary to have a certain amount of current passing through the armature, this amount depending upon the pressure. The current is measured by a unit called an ampere, the pressure by a unit called a volt, and the power by the product of the amperes and the volts. This product is measured by a unit called a watt. A current of one ampere and a pressure of one volt will develop a power of one watt. A current of ten amperes with a pressure of one hundred volts will develop a power of one thousand watts. This is what the current would do if there were no loss, but as part of the energy is expended in overcoming the resistance of the wire the full power cannot be recovered, we may therefore say that the watt is the measure of the theoretical value of the current and not the actual power it will develop, the latter depends upon the efficiency of the machine.

As the wire wound upon the armature has resistance, a part of the energy of the current will be used in forcing the current through the wire. The amount will depend upon the resistance. Resistance is measured by a unit called an ohm. A pressure of one volt will force a current of one ampere through a resistance of one ohm, and through ten ohms ten volts would be required to force one ampere. From this we see that when a current passes through a wire part of the pressure is used up in overcoming the resistance, and applying this to the armature it becomes evident, at once, that the counter electro-motive force cannot equal the direct electro motive force, but must be equal to the difference between this and the pressure required to force the current through the wire. If the load upon the motor is constant, the current passing through the armature will necessarily remain constant, and therefore the loss of pressure in overcoming the resistance will be constant, hence the velocity of the armature will not change as it will have to develop the same counter electro-motive force all the time; and this will do at a uniform velocity, providing the strength of the field does not change, and as we have shown this will not change so long as the pressure is constant.

If the load upon the motor is increased, more current will be required in the armature to put forth the extra power, but this additional current cannot be obtained unless the resistance is reduced. If the current is increased, the resistance of the armature wire will absorb a greater amount of the pressure, which will make matters worse, unless the counter electro-motive force is reduced. This is what must be done, but it can only be accomplished by reducing the velocity of the armature; therefore if the load is increased the armature must run slower, and if the load is reduced, it must run faster. The difference in the speed, however, can be made very small by reducing the resistance of the wire on the armature to the lowest point. This can be accomplished by making the wire large and having as few turns as possible. The turns of wire on the armature can be reduced by increasing the strength of the field in proportion, for as has been explained, the pressure developed by the armature is in proportion to the strength of the field and the number of turns of wire, and one can be reduced by increasing the other. If the armature wire has such a low resistance that the pressure absorbed by it when the motor is working to its full power is, say one per cent. of the total pressure of the current, then it is evident that if the load is doubled, which would require double the current, the loss of pressure in wire would only be increased to two per cent, therefore the counter electro-motive force would be reduced to the extent of one per cent and the speed would be one per cent lower than with the normal load. In the same way if the load were reduced to zero, that is if the motor were run light, the loss of pressure in the armature wire, which at full load would be one per cent, would be reduced to a very small fraction of one per cent, and as a result the counter electro-motive force would have to increase about one per cent, and this would require an increase in velocity of the same amount.

From the foregoing it can be seen that to obtain close regulation of speed in a shunt motor it is necessary to make the resistance of the armature wire as low as possible, and the same is true if the machine is a generator instead of a motor. In actual practice, as close regulation as one per cent between full load and no load cannot be obtained if the armature absorbs as much as one per cent of the pressure at full load, because there are certain other losses that tend to change the speed to a somewhat greater extent, but the difference is only slight.

While the shunt wound motor runs at a constant velocity with a constant pressure of the operating current, a shunt wound generator will develop an equally constant pressure if run at a constant velocity. Why it will do so can be easily understood, for suppose the motor just considered were run as a generator and at the same velocity as it ran as a motor, then the back pressure which would now become the direct electro-motive force would be the same as before and the pressure appearing at the commutator brushes would be equal to this amount less that absorbed by the resistance of the armature wire, which, as has been stated, would be one per cent. This pressure would maintain a constant current through the field coils, just as in the case of the motor, and the current passing to the external circuit would be free to vary without changing the electro-motive force developed by armature, since the velocity of rotation and the strength of the field would remain constant.

As a portion of the electrical pressure is absorbed in forcing the current through the wire it follows that if a generator is supplying current to a number of lamps, say one thousand feet away, the pressure at the lamps will be lower than at the generator. Furthermore, the difference in pressure at the two points will vary with the difference in strength of current. To illustrate, suppose the loss of pressure with a current of ten amperes is one volt, then with one hundred amperes it will be ten volts. If the pressure of the generator is 100 volts, at its terminals, it will be ninety-nine volts at the end of the line when the current is ten amperes, and only ninety volts when it is 100 amperes. This drop of pressure would render the current very unsatisfactory. If it were used for operating lamps, the result would be that with a few in use the light would be very bright and with a large number very dim. If used to run a motor, the speed of the latter would change considerably, as the pressure would drop as the load increased. To overcome this difficulty the compound winding is used for generators, and the differential winding for motors. In the compound winding, in addition to the shunt coils there are a set of series coils through which the whole current generated by the armature is passed. As can be seen the effect of these series coils is very small when the current generated by the armature is weak, for they then add but little to the total magnetizing force, but when the current is strong the assistance the shunt coils receive from the series coils is very great. By placing the proper number of turns in these coils any amount of drop of pressure in the line can be compensated for. In the example just given the turns in the series coils would be made sufficient to raise the pressure of the current to about 110 volts with

the current at 100 amperes, and then the pressure at the end of the line would be ninety-nine volts with a strong, as well as a light current. In a motor the series coils are connected so as to work against the shunt coils and this is why it is called differential winding. The action is as follows: If the current through the motor increases, in consequence of an increase in the load, the series coils as they work against the shunt, reduce the strength of the field magnetism, and therefore the counter electro-motive force developed at a given velocity is reduced, since a reduction in field strength reduces the electro-motive force. As by the reduction in field strength a lower counter electro-motive force is developed at the same velocity it follows that the normal speed can be kept up even if the pressure of the current drops, and as in the case of the generator, any drop can be compensated for by placing the proper number of turns in the series coils.

An oil tank steamer for the Standard Oil Co. will be constructed at the yard of John B. Roach, in Chester, Pa. She will be 264 ft. long, 40 ft. beam and 23 ft. 6 in. deep, and will have a capacity of 720,000 gallons. Triple expansion engines with cylinders 21 in., 34 in. and 56 in. by 42 in. stroke will be fitted, with two Scotch boilers 14 ft. 6 in. dia., and 12 ft. 9 in. long, giving steam at 180 lbs. pressure. The general arrangement will differ somewhat from that usually followed, in that the machinery will be placed amidships. Here, also, in a bridge structure, the officers will be housed. There will be bunker capacity for 550 tons of coal.

A fine new machine shop built by the Chicago Shipbuilding Co. consists of a central bay 60 ft. wide and 60 ft. high, served with overhead crane and 2 side bays 3 ft. wide. But three bents, or 120 ft. in length, of the shop have been built, but it can be extended as the necessity arises, to 450 ft. in length, or additional bays, on the saw-tooth roof principle can be added on either side, the iron work being designed for that purpose. The crane girder and columns are built to carry two 25 ton cranes working together. The shop has unobstructed floor room, there being but four columns in a space 120 ft. square. It is also remarkably light. The inside and the tools are painted white, and on a dark day, from the number of cross reflections, it is actually lighter than it is outside. The heating arrangement consists of a hot air system with steam coil and fan, installed by the American Blower Co., of Detroit. The 25 ton electric crane is by the Brown Hoisting and Conveying Machine Co., of Cleveland, O. In each side bay there is a 5 ton hand crane. The tools were nearly all furnished by the Niles Tool Works Co., of Hamilton, Ohio, and include a floor boring, drilling and milling machine of special design. The horizontal travel is 16 ft., vertical, 10 ft., and the spindle feeds in 6 ft., the bed plate being 20 ft. square, with an 8 ft. circular table having 3 ft. power cross feed. The big lathe is 72 in. swing by 25 ft. between centers, and there is the usual outfit of planers, slotters, radial drill, shapers, small lathes, etc. The small tools in each bay are served from one line of shafting, driven by a motor at the end. The floor boring machine and big lathe have separate motors attached. This leaves the main floor of the shop entirely clear of belts. All motors used are by the Elwell-Parker Electric Co., of Cleveland, Ohio, who also furnished the generator which runs them and the motors for the rest of the ship yard plant which was changed to motor drive in all departments on the central power house system when this shop was finished. The shop was designed by the Wellman-Seaver Engineering Co. in accordance with the suggestions of W. J. Babcock, manager of the company, and was built by the ship yard force.

ENGINEERS' DICTIONARY.—III.

Banked Fires.—A condition of the fires in the furnaces of a boiler in which all the combustible is heaped up on one part of the grate and covered with fresh coal, the dampers and draft regulators being so arranged as to allow only very slow combustion. Under these conditions, when there is little or no demand for steam from the boilers, the temperature and pressure can be maintained with but slight active formation of steam, while on the fires being spread and the draft applied, steam will be rapidly formed for use as may be required. Fires are usually banked during stops of a few hours, or when for any purpose it is desired to maintain the machinery in a condition to get under way with the least possible delay.

Bearing.—A general term applied to such portions of a machine as are used to support or constrain a rotating shaft. It is also frequently used in a wider sense as a general name for any surface which provides support or constraint. Using the term in the first sense, the most important bearings in a marine engine are those for the shaft. The bearings for the crank shaft are called *crank shaft bearings*, *main bearings*, or *main pillow blocks*. The bearings aft of the engine and used chiefly for the support of the shaft are called *spring* or *line shaft bearings*. The bearing formed where the shaft passes out through the stern, or through the side with twin screw ships, is called the *stern* or *outboard* or *tailshaft bearing*. The bearing formed in the after supporting bracket used with twin screws, is called the *after* or *stern bracket bearing*. The bearing provided for transmitting the thrust from the shaft to the ship is called the *thrust bearing*.

Bearing Bars.—Bars running across the furnace of a boiler for the support of the grate- or fire-bars.

Bed Plate.—In general the base or foundation part of an engine or other machine. With the usual type of marine engine, the bed plate supports the columns on either side, and serves to connect them with the engine-seating as part of the ship, while along the center it supports the crank shaft bearings or pillow blocks. The bed plate must provide sufficient strength to withstand the internal stresses arising in the engine, and sufficient stiffness to prevent sensible bending or departure from the lines of correct adjustment. Cast iron and cast steel are the usual materials used, the latter to a slowly increasing extent.

Bell Crank.—A bent lever, as illustrated by A. B. C. in Fig. 4, for changing the direction of reciprocating or to and fro motion. Frequent examples are met with in indicator reducing gear, starting gear, etc.

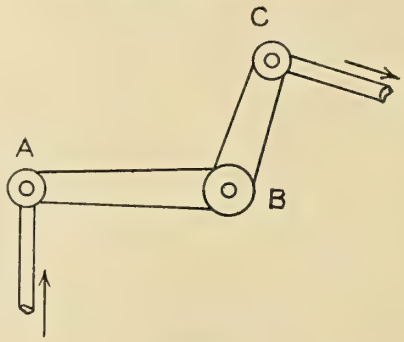


FIG. 4.

Bilge Injection.—A valve and pipe for connecting the circulating pump inflow with the bilge. By this means the circulating pump may be used as a bilge pump in case of emergency.

Bilge Ejector or *Bilge Siphon.*—(Fig. 5.) A form of steam "injector," used for clearing the bilge of water. A is the steam pipe, C the nozzle, B the pipe leading to the bilge, and D that leading to the discharge. Such an arrangement can lift the water but a small distance, and for best results should be put down near the level of the water to be handled.

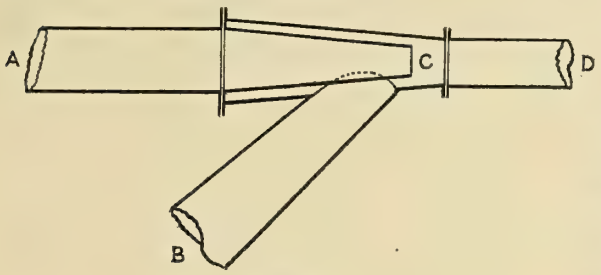


FIG. 5.

Bilge Suction.—A general term applied to the pipe leading from a bilge pump to the *well* or point of inflow.

Black Lead.—A common name for *graphite*, one of the forms of carbon. Graphite is much used as a lubricant in modern engineering practice, either alone or in combination with grease or oil. It is also used as the base of paints for metallic surfaces.

Bleeder.—A pipe leading from the main steam pipe direct to the condenser. It thus constitutes a *by-pass* or shunt for the steam past the engine. It is used to control the steam pressure in the boilers when stopping, or when lying with heavy fires and ready to get under way. Its use avoids the necessity of opening the safety valve, with the consequent loss of steam through the escape pipe, and the resulting loss of fresh water from the boiler. The air and circulating pumps must, of course, be independent of the main engine in order to make use of such a device.

Blow Cock or *Blow Valve.*—A cock or valve allowing water to be blown or forced through the *blow-off pipe* out through the bottom or side of the ship, and thus discharged from the boiler. When the pipe is led from the bottom of the boiler the fitting is called the *bottom blow* or, sometimes, the *mud blow* or *mud cock*, and it is used to remove mud sediment and scale from the bottom of the boiler. When the pipe is led from near the surface of the water in the boiler it is called the *surface blow* or *scum cock*, and it is used to remove the oily scum which gradually accumulates in all marine boilers on the surface of the water. Modern marine boilers are usually fitted with both bottom and surface blows. All blow-off pipes should have as straight a lead as possible, and should be fitted with plug-cocks or straight-way (the latter preferably) rather than globe valves. Their size should preferably not be less than 2 in. to 2 1-2 in. dia.

Blower or *Fan.*—A machine for handling large volumes of air under light pressure and used for the ventilation of ships, forcing the draft of boilers, etc. The modern blower consists of a shaft carrying several blades or fans, surrounded by a casing and operated by an engine usually attached to the casing or to the same bed plate. The direct result of the revolution of the fan is a corresponding revolution of the air, in consequence of which the centrifugal force developed causes a movement toward the tips of the blades or outer shell of the casing. An outlet is here provided, and hence the air escapes, driven by the pressure due to the centrifugal force. Its place is taken by air entering at the inflow near the center of the fan, and so long as the latter is in motion the result is a continuous stream of air from the outlet issuing at a velocity depending on the speed of the fan and other circumstances.

QUERIES AND ANSWERS.

Q.—The engines of my ship, when towing a barge, make 68 revolutions per minute, and when not towing make 73 revolutions per minute; the steam and vacuum and everything being the same. Where does the loss of horse power come in? By figuring at 68 revolutions I get considerable less than 73 revolutions. TEXAS.

A.—For the explanation of the conditions which you describe, let us assume certain data which you have not given.

Suppose the resistance of the barge to be 70 per cent. that of the ship, and that with the barge the speed attained is 8 knots. Then without the barge the resistance of the ship at this speed will be $\frac{100}{170} = .588$ of the total value with the barge. Supposing resistance to vary about as the square of the speed, then the speed at which the ship alone will have the same resistance as the ship and barge at 8 knots, will be not far from $8 \times \sqrt{1.70} = 10.4$k. Suppose furthermore, the pitch of the wheel to be 17 ft. Then at 10.4 knots and 73 revolutions the slip will be 15 per cent., while at 8 knots and 68 revolutions the slip will be 30 per cent. We can now explain what occurs:

Suppose the ship towing the barge at 68 revolutions and 30 per cent. slip and making 8 knots with a certain steam pressure and position of cut-off. Then, with no change in the steam or cut-off, suppose the barge to be cast off. The mean pressures, turning effort, and thrust remain the same. The resistance of the ship, however, is now less than the developed thrust, and she will, therefore, increase in speed and revolutions until a new condition of equilibrium is found at a speed of 10.4 knots, 73 revolutions, and 15 per cent. slip. While the thrust and resistance are therefore the same as under the former conditions, the speed has increased from 8 to 10.4 knots or by $2.4 \div 8.0 = 30$ per cent. of its former value, and hence the useful work has increased in the same proportion, while the required work in the engine has only increased, due to the rise of revolutions, or in the ratio $5 \div 68 = 7.4$ per cent. that is, the work required to drive the ship 10.4 knots at 73 revolutions and 15 per cent. slip is 7.4 per cent. greater than that required for the ship and barge at 8 knots with 68 revolutions and 30 per cent. slip, and this increase of 7.4 per cent. in the required work is attended by an increase of 30 per cent. in the useful work. The loss of work in towing comes therefore from the necessarily high value of the slip, and consequent low propulsive efficiency. The reference of the problem to the speeds developed in the two cases shows plainly their relation, and why more power is developed light than loaded at the same steam pressure. The figures assumed above are merely illustrative; the same principles, however, will apply to any other values so long as they are mutually consistent.

Another illustration of these principles is found in the fact that with a vessel tied to a dock, as in a machinery dock trial, the revolutions and power developed are less than when in free route with the same steam pressure.

Q.—In using soft coal under the boilers on tugboats I find that the tubes and smoke box get clogged up with a deposit of soot, which shuts off the draft, causing the boiler to steam hard. The tubes must be swept either by hand or steam about every other day. I suppose this soot is a deposit of hydrocarbons from the smoke, and would like to know if there is any element or compound which, if introduced under the boiler, might eliminate this objectionable deposit. How would it do to burn zinc occasionally? Please also advise what the composition of the average soot from bituminous coal is, and why anthracite coal does not leave a deposit in the tubes? H. B. Y.

A.—As you suppose, soot is a deposit or precipitate from unconsumed or partially consumed hydrocarbon gases. Stating the formation in chemical language, it may be said that if an unoxidized or partially oxidized hydrocarbon gas is suddenly cooled, the carbon is precipitated out in an amorphous or noncrystalline form, and is deposited on the surfaces from which the cooling action comes. Soot is much more abundant with soft or bituminous coal than with anthracite, simply because the former is rich in hydrocarbon compounds, and the latter poor. A true anthracite coal has little or no hydrocarbons, and hence produces no appreciable soot, while on the other hand, the richer a coal in such compounds, the more extensive may be the soot formation. The principal constituents of soot are carbon, volatile matter and ash. The relative proportions are quite variable, dependent on the special conditions. The volatile matter is simply a certain portion of hydrocarbon gas which is presumably absorbed by the other constituents without precipitation of the contained carbon. The ash is simply a part of the non-combustible matter in the smoke which is caught and mechanically mixed with the other constituents.

The only way in which the deposition of soot can be prevented is by a complete oxidation or burning of the hydrocarbons before they reach the relatively cool tubes. If the carbon is all oxidized to the form CO_2 or carbon dioxide, it cannot be precipitated out as soot. One of the chief purposes of the combustion chamber is to provide a place where such combustion may be completed. In order to accomplish this, however, the temperature must be maintained very high, and an intimate mixing of the gases given off by the coal with free oxygen in the air supply must be brought about. It is for this purpose that recently use has been made of bundles of small jets delivering hot air under high pressure into the furnaces or combustion chambers. These act as so many mixers or stirring rods, and are intended to bring about the intimate mixture necessary for complete combustion.

Once deposited, we know of no better way for the removal of soot than by the steam or hand sweep. The resources of chemistry do not so readily adapt themselves to its removal as might be expected. The burning of substances like zinc would result in the oxidation of the zinc in the furnace, and its partial reduction back to metallic zinc on the soot, the corresponding amount of soot being thereby removed as carbon dioxide. This would result in a deposit of metallic zinc with the soot, for the action would be only partial, and the soot removed would, in our opinion, be out of all proportion, small in comparison with the cost of the zinc burned.

Q.—What would be the gain in saving of fuel by putting in an iron coil feed heater in the smokestack, to by-pass through before entering the boiler?

MUSKEGON.

A.—The gain to be derived from the use of a feed water heater cannot be stated off hand, or in general terms, as it will depend on the particular circumstances of the case. The especial purpose of the heater is to absorb by the cool feed-water a portion of the heat which would otherwise escape up the stack. If then the supply of heating surface in the boiler is abundant and efficient in action and the gases are delivered to the base of the stack at a fairly low temperature, such, for example, as 450 deg. to 500 deg. the gain to be derived from the use of the heater would be small. If on the other hand the heating surface is deficient in amount or inefficient in action, and the gases are delivered to the stack at a temperature of 700 deg. to 800 deg., the gain by the use of a properly designed and fitted heater would be pronounced. In no ordinary case, however, will the gain be more than from 15 to 20 per cent., while in the cases commonly met with, a gain of half these figures would be considered quite satisfactory.

The most important secondary point in connection with a stack feed heater is its possible influence on the draft. If the space within which the heater is to be fitted cannot be made considerably larger than the cross section of the stack itself, a decrease of the area for the passage of the gases will result, and a consequent loss of draft, unless made up by aid of a blower. The heater should be so fitted that the net cross sectional area between the pipes is at least as great as, and preferably greater than, that of the stack.

Q.—Will you please give me the rule for finding the pitch of a propeller?

W. C., Boston, and W. H. C.

A.—To determine the pitch of a given propeller three measurements are necessary. These are:

(1.) The radius O A at which the pitch is desired.

(2.) The angle or part of the complete circumference corresponding to the distance on the blade between A and B. The two points between which the pitch is to be found.

(3.) The advance B C along the line of the shaft, corresponding to this part of the complete revolution.

In the figure, A and B are points on the face of the blade, and are at a constant distance O A from the shaft center line O O. A C is an arc of a circle which lies in a plane through A, and perpendicular to the shaft. The angle A O C is therefore the one referred to in (2), and the distance B C is the corresponding advance. Then B C is the same fraction of the entire pitch that A O C is of a complete circle, or that the length A C is of a complete circumference with O A as radius. This complete circumference will be $6.2832 \times$ O A. Hence the proportion:

$$A\ C : 6.2832\ O\ A : : B\ C : \text{pitch}$$

$$\text{or pitch} = \frac{6.2832 \times O\ A \times B\ C}{A\ C}$$

A C is, however, not as easy to measure as A B, so that we may put for A C its equal, $\sqrt{\overline{A\ B}^2 - \overline{B\ C}^2}$ and hence

$$\text{pitch} = \frac{6.2832\ O\ A \times B\ C}{\sqrt{\overline{A\ B}^2 - \overline{B\ C}^2}}$$

A brief outline of the operation is as follows: (1) Select the points A and B at and between which the pitch is desired, making sure that O A = O C, and lay out on the blade a line A B at a constant radial distance equal to O A from the center line of the shaft. This can be done by squaring down from a straight-edge or other reference line P O P R placed across the hub and at right angles with the shaft. Measure the length A B.

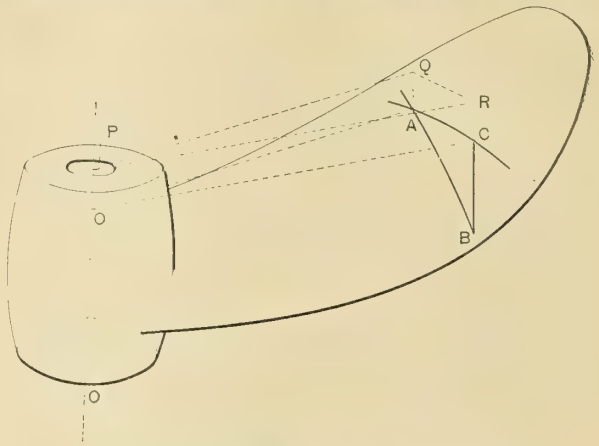
(2.) The propeller being leveled up, measure the distance B C from a level through A vertically down to B. Or if the propeller cannot be leveled, measure from B in a direction parallel to the shaft out to a line through A and running at right angles to the shaft. Or measure from Q down to A and from R down to C, and take their difference B C.

(3.) Multiply the radius O A by 6.2832 and by the length B C all in the same units of measure.

(4.) Square the lengths A B and B C, subtract the square of the latter from that of the former, and take the square root of the remainder.

(5.) Divide the result found in (3) by that found in (4) and the result will be the pitch desired.

Thus for example suppose A B = 15 inches, B C = 9 inches, and O A = 40 inches. Then $6.2832 \times 40 \times 9 = 2262$. Also $\sqrt{225 - 81} = 12$ and $2262 \div 12 = 188.5$ inches $= 15.7$ feet = pitch.



SKETCH SHOWING METHOD OF FINDING PITCH.

The foregoing assumes the propeller to be of uniform pitch. If instead the pitch is variable, the operation is precisely the same, but the result found must be considered merely as the mean or average value of the pitch between the points A and B. For other parts of the blade a similar process will give the corresponding pitch.

As a rough and ready rule it may be remembered that the pitch of a propeller will equal the length of a circumference at the place on the blade where the slope of the face is 45°, or where it is equally inclined to the shaft and to the transverse direction. Starting near the shaft the inclination to the longitudinal is small, but increases toward the tip. Let r be the radius where the inclination is the same to both directions, then $p = 2\ \pi\ r = 6.2832\ r$. In this way an approximate idea may be obtained of the pitch of a wheel by estimate without special measurement, except for the radius or diameter at which the condition of equality of slope is fulfilled.

The details of the general method as described may be varied in many ways, but the description given will serve to show the general principles involved, and with a reasonable amount of mechanical skill, no trouble will be found in carrying out the measurements required.

Q.—To whom should one apply for a position as oiler on the American liners St. Paul or St. Louis? Also what qualifications are necessary to secure such a position? J. E. L.

A.—The oilers on the ships you name are men who have been promoted from firemen, and the firemen are usually engaged from a shipping master. On the big ships they usually like to have only men who have had sea experience. If the applicant has not had such experience, it would be better to try for a position as oiler on a coasting vessel or on a transatlantic freighter, as these boats will take new hands, usually by applying to the Chief Engineer. The work would be much lighter and much valuable experience could be secured. No special qualifications are required, other, of course, than good health, a record for sobriety, and average intelligence; but chances of promotion are slim, in the transatlantic trade, unless the applicant has received a good training as a machinist.

The Engineer's Reference, published by the Reference Publishing Co., World Building, New York, is the name selected for a most complete directory, properly classified and indexed, of manufacturers and dealers in all kinds of materials and apparatus, used in and about steam and electric plants, in the Greater New York. It is a valuable guide in the purchase of supplies and apparatus, giving in a convenient form the names of responsible concerns in this line of trade.

DURING THE MONTH.

The new steamer for the Catskill and New York Steamboat Co., for which W. & A. Fletcher, of Hoboken, have the contract, will be named the "Onteora."

According to present indications, the insolvent Anchor Line, operating steamers on the Mississippi between St. Louis and New Orleans, will be reorganized and new boats added to the fleet.

The torpedo boat MacKenzie was launched at the yard of the Hillman Ship and Engine Building Co. She is a 100 ft. boat, fitted with a single screw, and is expected to develop a speed of about 20 knots.

When the American liner New York was being got ready for her trip out on February 2 a flaw was discovered in the port thrust shaft. The sailing date was canceled, and the ship taken over to Jersey City to await a new shaft, which was immediately ordered.

A contract for the construction of a steamship for the Virginia and Carolina Chemical Co. was awarded Harlan and Hollingsworth. Her dimensions are given as: Length, 275 ft.; breadth, 41 ft.; depth, 22 ft. The machinery is to consist of a triple expansion engine 18 in., 28 in. and 45 in. by 42 in. stroke, working at 160 lbs.

The Manhattan Steamship Co., organized to operate a line of steamers between New York, Maine and Canadian ports, is figuring on plans for new steel vessels. The officers of the new company are: Jonathan J. Hillman, president; Joseph D. Huggins, vice-president; N. L. Newcomb, general manager; Henry E. Alexander, treasurer, and William F. Weiss, secretary.

At the yard of Harlan and Hollingsworth, in Wilmington, the twin screw steam yatch Niagara, for Howard Gould, of New York, was successfully launched. This powerful vessel is 272 ft. long, 36 ft. beam, and 27 ft. deep. She will be fitted out in modern style, and in the points of comfort and convenience especially will be one of the finest pleasure vessels afloat.

Plans for a new lake steamer for Captain John Mitchel and others are now being worked out by the Globe Iron Works Co. at Cleveland. This vessel will be a large freighter, and will have a machinery equipment designed somewhat upon the lines of the machinery of the S.S. Inchmona, referred to in our last issue. This will include boilers to carry 230 lbs. pressure, fitted with hot draft and quadruple expansion engines.

The sale of the steam yacht Mayflower (described in our issue of August, 1897), the property of the estate of the late Ogden Goelet, to a European agent was effected through Tams and Lemoine, of New York. The price paid is said to have been $400,000, and the new owner to be none other than Leopold, King of the Belgians. The yacht, which has been lying at the Erie Basin, is a large sea-going vessel, luxuriously fitted up. She is a squat-looking boat, however, and is fitted with a rig disproportionately small for the size of the hull.

A table of the number of cabin and steerage passengers landed at the port of New York by the transatlantic steamship lines, prepared by W. C. Moore, landing agent at the Barge Office, shows: The Cunard Line, in 61 trips, carried 15,196 cabin and 17,303 steerage; the North German Lloyd, in 112 trips, carried 12,589 cabin and 25,542 steerage; the American Line, in 53 trips, carried 14,443 cabin and 11,322 steerage; the White Star Line, in 53 trips, carried 10,104 cabin and 19,271 steerage; the Hamburg-American, in 88 trips, carried 10,556 cabin and 15,270 steerage; the French line, in 52 trips, carried 6,044 cabin and 14,264 steerage, and the Anchor Line, in 40 trips, carried 6,450 cabin and 4,400 steerage. The other lines ranged variously, from a total for the Holland-American, for all classes, of 11,468, to the Bordeaux Line, with a total of 960 passengers.

Arrangements were made for the establishment of a regular steamship line from New York to ports in China and Japan, via the Suez Canal. Several steamships averaging about 5,000 tons have been chartered for the service. The ports of call will be Singapore, Hong Kong, Shanghai, Kobe, Yokohama and Rea Sea ports. While steamers are now leaving New York with more or less regularity for these ports they are chartered for the outward trip only, so that this new line will be the first regular steamship line to the far East from New York. Funch, Edye & Co. will be the New York agents. General cargoes will be carried.

Another screw propelled ferryboat is to be built by the Pennsylvania Ferry Co. for the Twenty-third street service in the North River, New York. The contract was signed with John B. Roach, at whose yard in Chester the new boat will be constructed. The ferryboat will be 206 ft. long, of steel, with twin engines driving four screws, two at the bow and two at the stern. The boiler equipment will consist of four Thornycroft water-tube boilers. The boat will be double decked and finely finished; in fact, a counterpart of the vessel recently built at Philadelphia for this route.

The Port Arthur and Mexican Steamship Co. was incorporated for the purpose of running steamers from Port Arthur to the Mexican ports of Tampico, Vera Cruz and Progreso, in connection with the Kansas City, Pittsburg and Gulf Railroad, running between Kansas City and Port Arthur. The Themis, carrying about 2,600 tons and having passenger accommodation for about ten persons, has been chartered, and the steamship company is negotiating for a second vessel of about equal dimensions, so as to have semi-monthly sailings. Steamer wil commence running about the middle of March.

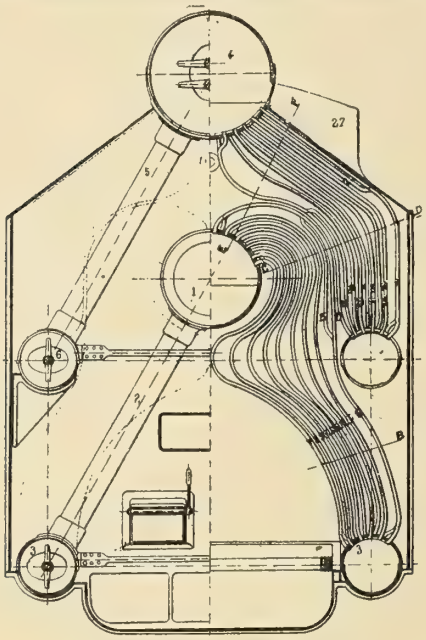
Alterations were commenced in the machinery equipment of the lake steamers Owego and Chemung. These large boats originally had six boilers capable of collectively furnishing steam for 3,000 horse power, or sufficient to run the vessels at 16 miles an hour loaded. This was a higher speed, however, than the conditions of business made necessary, and so the ships are at the Union Dry Dock in Buffalo to have their boiler power cut in half. Three boilers will be left in each, though rearranged as to position, and this will bring the speed down to about 12 miles an hour, and the consumption of fuel very considerably. Less crew also will be needed, and the owners expect to hold their own in the freight business by these alterations. Structural changes will also be made in the boats, so that they can carry iron ore as well as package freight, for which latter they were originally designed and built.

An unusual sight was the presence of two of the largest steamships in the world in New York harbor at the same time, both having made maiden voyages. One of these was the Cymric, the gigantic freight and passenger steamer of the White Star Line, just out from the yards of Harland & Wolff, the builders, at Belfast. She is a new departure for the transatlantic trade of the White Star Line, being of the intermediate class, with great cargo space, large accommodation for a few passengers, and moderate speed. Her dimensions are: Length, over all, 600 ft.; beam, 64 ft., and depth, 42 ft. Her gross tonnage is 12,551 tons. Her speed during the run out from Liverpool averaged 11.53 knots. There was a heavy fog during the last days of the trip or she would probably have made better time. The other vessel was the Pretoria, of the Hamburg-American Line, a German built sister ship to the Pennsylvania, which was illustrated and described in our issue of April, 1897.

SELECTED PATENTS.

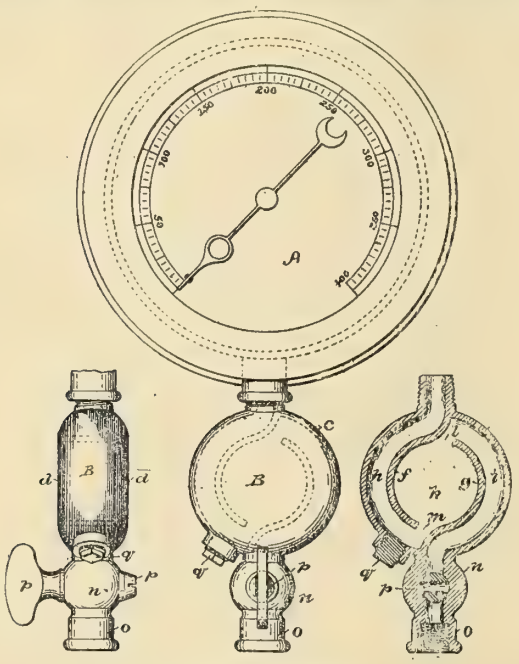
596,865. STEAM-GENERATOR. *Charles Ferrand, Paris, France. Filed July 17, 1897.*

A steam-generator comprising two multitubular boilers each composed of an upper collector and two



FERRAND WATER-TUBE BOILER.

lower collectors, the collectors being connected by water-tubes forming fire-screens, one of the boilers being arranged above the other and both having a common grate, the boilers having separate and independent water-inlets and steam-outlets, the arrange-



ALMY STEAM GAUGE.

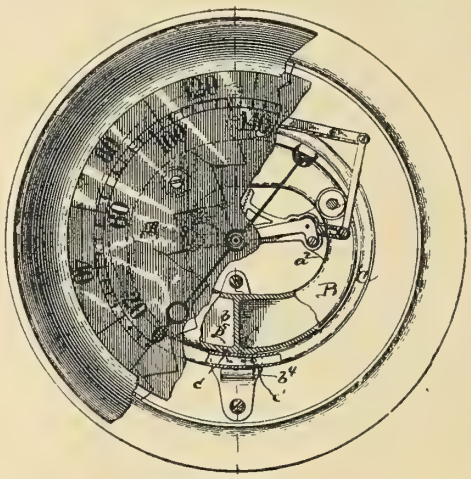
ment being such that the escaping flames and hot products of combustion after first heating the lower boiler operate to heat the upper boiler. A steam-generator composed of two multitubular boilers, the system of tubes of the lower boiler being formed by four groups of tubes, crossing each other and constituting the sides of the combustion-chamber; this arrangement being especially suitable for distributing the heating effect resulting from the direct contact with the fire and less apt to rapidly cool the hot gases from the furnace.

596,674. PRESSURE-GAUGE. *Charles B. Bosworth, Everett, and Joshua H. Millett, Malden, Mass., assignors to the Crosby Steam Gauge and Valve Company, Boston, Mass. Filed January, 24, 1896.*

In a pressure-gauge the combination of a Bourdon spring, with a water-chamber entirely located within the curve of the spring. The combination of the water-chamber and a Bourdon spring arranged one within the other and having a water-passage connecting the two, the water-chamber being provided with a boss or extension, such boss being provided with a passage leading into the water-chamber and a passage leading from the Bourdon tube.

595,844. STEAM-GAUGE. *Darwin Almy and Frank D. Almy, Providence, R. I. Filed January 19, 1897.*

The combination with a steam-gauge, of a hollow shell, of approximately circular form, having two oppositely-disposed openings, and partitions, dividing the interior into the passages *i* and *u*, extending along the outer periphery of the shell and the central circular space *k*, whereby the water of condensation is



CROSBY STEAM GAUGE.

collected in the central space, the channel connecting with the gauge connects with the central water-space at the lowest part of the shell and the steam acts on the water in the central space at the highest part of the shell, as described.

BOOK NOTICES.

High Pressure Hydraulic Fittings, manufactured under Folly's patents, are described in a neat little pamphlet of 85 pages issued by the Tight Joint Co., 159 Bank street, New York. It also contains information for use in designing hydraulic plants of a very valuable character. In the first section of the pamphlet the sizes of the joints carried in stock, with sectional sketches, are given. This is followed by convenient tables of circumferences, areas, squares, etc., for ready reference, and then come a number of pages of hydraulic memoranda with working formulæ. Hydraulic Pressure Transmission is discussed in the closing chapter, which covers many practical points concerning pumps, accumulators, valves and connections, and hydraulic machinery, such as presses, shears and punches. The little book, which is edited by John Platt, M.E., is really a most convenient manual, and represents very effectively the power of compression—getting much into small compass.

Mechanical Draft, a practical treatise, is a well chosen title for a 385 page book issued by the B. F. Sturtevant Co., the well-known manufacturers of blowers of Boston and New York. Its purpose, of course, is to exploit the manufactures of the house, but there is a manifest desire to subordinate this feature of the work to the practical scientific consideration of the subject. It is indeed most timely, for there is now a great awakening to the advantages to be obtained, in the points of economy and convenience, by having means of regulating absolutely the coal consuming capacity of steam generators. The ship so fitted, for example, is independent of weather conditions, and can adjust its consumption of fuel to meet varying demands with a nicety. The work is sufficiently theoretical to interest the studious, and yet not too heavily loaded with disquisitions to discourage the more practical reader. Its simplicity is indeed remarkable. The subject is subdivided into chapters, which cover Water, Steam, Combustion, Fuels and their efficiency; also Efficiency of Steam Boilers, Rate of Combustion, Draft, Chimney and Mechanical Draft, and, finally, an explanation of the various fans manufactured by the company and illustrations of their application. It is a book of real value to the superintending or constructing engineer.

The Arithmetic of the Steam Engine, by E. Sherman Gould, contains, in the words of the author, "the fundamental principles of the steam engine, and the practical calculations based on them." Although styled an arithmetic, its use bespeaks a working knowledge of elementary mathematics, but only to the extent that the subject really demands. It would be a primer to the theoretical physicist, but is a helpful aid for the practical engineer who has aspirations. Brief chapters on Heat and Ice are followed by the division of steam, which treats in turn of Pressure and Volume, Combustion, Efficiency of the Steam Engine, Indicator Diagrams, the Compound Engines, etc. Tables are added, giving properties of Saturated Steam and Hyperbolic Logarithms. D. Van Nostrand & Co., of New York, are the publishers, and $1.00 is the selling price.

Valve Setting Record Book, by P. A. Low, is one of those conveniences which enable the chief engineer to note with exactness the adjustments which are made from time to time in the gear of the modern marine engine, and consequently the resulting changes in efficiency. These, of course, could be noted in any pocket book or on separate sheets. To have a memo. in book form, however, giving all the measurements needed, without the necessity for loss of time and temper in searching for separate records, which are never to be found when wanted, is cheap at the price offered—60 cents. The book has blanks for the data concerning any style of screw engine up to and including a quadruple. Its publishers are Spon and Chamberlain, 12 Cortlandt street, New York.

The Marine Review, Cleveland, Ohio, recently issued its annual report of ship building now under way in all parts of the United States. It is a double number, with two 14 in. × 20 in. enameled paper supplements, containing half page illustrations of the officers of the Society of Naval Architects and Marine Engineers, a group of twenty-one ship builders, and a group of marine business men. Views of the principal ship yards of the United States and their products are also shown, together with a reproduction of an oil painting of the Kaiser Wilhelm der Grosse in the original colors. Extra copies can be had by enclosing 20 cents to the Marine Review.

A reference catalogue of the Scientific American Supplement has been received from Munn & Co., publishers, 361 Broadway, New York, which, according to the prefatory note, contains over ten thousand important articles. These cover a field as wide as science itself, and in themselves form a convenient and valuable reference library.

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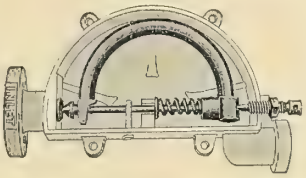
costs money. If wasted for want of a good steam trap—means just that much profit actually burned up in your boiler. Prevent it? Of course you can. Use the "Heintz" Steam Trap on all outlets; saves steam, allows no waste of hot water. You can take a "Heintz" on thirty days' trial—or buy one, use it a year and if not satisfied, return the trap—we return your money. Did we ever return it? No, never asked to; but it has been our guarantee, and we are always ready to meet it.

Booklet "G" will tell our story further, and we would like to send you a copy.



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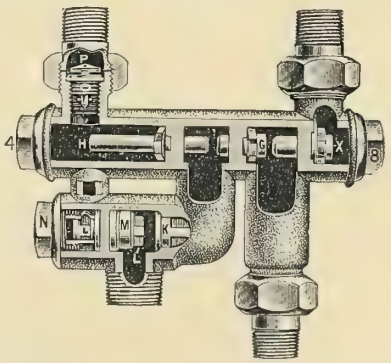

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TRADE PUBLICATIONS.

Pamphlets have been issued regarding the Harthan metallic rod packing manufactured by the Warren Mfg. Specialty Co., Warren, Mass. The packing is illustrated and fully described in this pamphlet.

A fine miniature steel engraving of George Washington was sent out last month by the A. W. Harris Oil Co., Providence, R. I., as a Washington birthday memento. The size of the card was 6 1-2 in. by 7 in. Probably not all the copies are gone yet.

A steel engraving of a four-masted ship is received from Wilcox, Crittenden & Co., Middletown, Conn. It is an exceptionally fine piece of work, 11 in. by 14 in. in size, and is one that every marine engineer who sends for a copy would want to have framed.

Users of steam packing should have a copy of the catalogue issued by the American Steam Packing Co., 60 Federal street, Boston, Mass. It comprises 25 pages and is well indexed. Packings of many makes and for all uses are fully illustrated and described, and there is other information of value to an engineer.

A pocket size catalogue and price list of engineering specialties has been issued by the D'Este & Seeley Co., 29 Haverhill street, Boston, Mass. It comprises 32 pages closely printed, and with each device fully illustrated. Several of the devices are particularly adapted to marine work. Copies of this catalogue should be sent for by all engineers.

A neatly embossed cover makes the centrifugal pump catalogue issued by the Lawrence Machine Co., Lawrence, Mass., unusually attractive. The catalogue comprises 48 pages, printed in two colors. The various types and sizes of pumps manufactured by this company are fully illustrated, and there is much other valuable information for engineers.

The subject of electric heating is fully handled by the catalogue issued by the Consolidated Car-Heating Co., Albany, N. Y. This catalogue illustrates a full line of electric heaters of all types and adapted to all uses and conditions. Because of the large amount of reading matter the subject is thoroughly elucidated and is fully illustrated.

An 1898 pocket calendar has been issued by the Knowlton Packing Co., 19 Pearl street, Boston, Mass. These calendars have much valuable information regarding the subject of packing, postal requirements, etc., in addition to the calendar feature, which extends through the year, and several memorandum pages. Copies of the book can be had upon application.

A very handsome little catalogue is received from th Ingersoll-Sergeant Drill Co., 26 Cortlandt street, New York, regarding the air compressors of various types manufactured by this company. These comprise all sizes, and are suitable for all kinds of work. The catalogue is finely printed on heavy coated paper and has a rich green cover with letters in gold.

"The Fastest Yacht in the World, the 'Ellide,' Running 40 Miles an Hour," is the brief wording accompanying a picture of this famous boat in running at this speed, and forming a part of a calendar issued by Charles D. Mosher, No. 1 Broadway, New York. On each side of the calendar are pictures, one of an engine and the other of tne Mosher water-tube boiler.

Handsomely printed circulars of electric plants of various types have been published by the New Britain Machine Co., New Britain, Conn., manufacturers of the Case engine. In these circulars different makes of electrical apparatus are illustrated, direct connected or belted to this engine. Engineers who have to do with electric plants will find these circulars of interest.

Labor or Steam

wasted in your plant? Suppose you had a hundred men on your pay roll, and fifteen to thirty doing nothing—"air punchers"—how long before you would weed them out? Yet, that's your proportion of loss in power when you run a plant without the "Heintz" Steam Trap.

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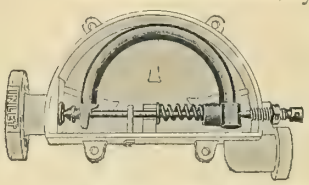

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